PUBLIC-SUPPORTED COTTON RESEARCH

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The opinions expressed by the participants at this conference are their own and do not necessarily represent the views of the U.S. Department of Agriculture.

COMMUNICATIONS—KEY TO THE FUTURE

By James H. Anderson[1]

In the next few seconds, I'd like each of you to identify in your own mind what you consider to be the most critical problem facing the agricultural community. If we were to write down your ideas, I suspect we'd have a long list of problems because there is great divergence of opinion on this question. In my own opinion, one of the greatest problems—perhaps the greatest problem—is communicating with the consumer or the general public. I doubt if many of you listed this as a critical problem facing agriculture. I'd like to explain why I believe it is of paramount importance and why I feel that each of us has a stake in it.

Most of us do not give much thought to communicating with the general public. As scientists we are more concerned about communicating our results to the scientific and agricultural community, and we give little thought to the general public. In fact, many of us have an erroneous idea of what communication really is. We tend to think of communication as the presentation of a manuscript, a speech, a radio program, or a television program. This is not communications; it is simply part of the mechanics of communication. Communication is the conveying or transmitting of ideas from one person to another or to a group of people. Unless an idea or concept is transmitted, no communication takes place. I can talk with you for the next 2 hours, but unless I convey ideas to you, I have not communicated with you. Communication, then, is the key to changing people's ideas or opinions about a particular subject or event.

It should not be surprising to most of us that we attach little importance to communicating with the nonagricultural public. Most of you here are scientists who have directed your communications to the scientific and the agricultural communities. Obviously, you have been effective, because the results of your work have contributed to the greatest revolution that has ever taken place in the history of mankind—the agricultural revolution.

In the future, communicating with the scientific and the agricultural communities will continue to be important, but it will not be enough. The balance of power is no longer with the agricultural community, and it never was with the scientific community. We are living in a new era, and if we are to continue to gain support for agriculture we must become increasingly concerned about communicating with the consuming public. The balance of power is with the consumer, and I believe his wishes will prevail in the final outcome. Consequently, we must develop effective communications with the consumer, and we must make our programs responsive to his needs.

It will be difficult for you and me to communicate effectively with the consumer group. We have little experience in this area, and the consumer, in general, identifies negatively with agriculture. He is bombarded with information from morning until night, and the messages he receives are often conflicting and garbled. He's not receptive to a barrage of additional information about a subject he does not understand. Furthermore, the consumer does not operate on the same wave length as the scientific community. For example, we will have little difficulty communicating with each other during the next 2 days in this meeting. Why? Because we are interested in a common subject. We have a common interest; consequently, we are on the same wave length. The majority of the general public has little interest in the subject matter of this meeting.

To be effective, we must speak to the consumer, not from the viewpoint of farmers' welfare, but from the consumer's own viewpoint. We

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must put ourselves in the place of a person who doesn't know farm problems and often doesn't care about them. We must show that person two points of vital interest to him.

First, that the real cost of his food and clothing—his bill for almost everything produced on a farm—is lower than it has ever been, and far lower than in most other nations. I recently saw a comprehensive study of how the final cost of a head of lettuce was determined. Although the cost to the homemaker was 39 cents, the farmer got only 4 cents for producing that head of lettuce. This dramatic fact, and similar facts on other products, should be driven home to the nonfarm public.

Second, we must make it clear to the consumer that it is in his own interest that legislators, executors, and judges representing him do not burden agriculture with unnecessary restrictions and regulations. The American people must realize that pesticides and insecticides are necessary if the farmer is to provide the food and fiber needs of the Nation. In other words, we must convince the public that the trade-offs are in their favor and that we intend to keep it that way.

How do we in agricultural agencies help to tell the farmer's story to townspeople, big-city dwellers, and suburbanites? I think the first step is to realize that the information, in whatever form, should be developed toward the goals I just mentioned. We should not slip back into what might be called the farm framework; instead, our efforts should be in the consumer framework. We need to—we must—learn to think about agriculture from the other end, the consumer end.

Experiment station and extension service activities offer almost limitless possibilities for informing the nonfarm public about agriculture. Editors can search out stories with a lot of intrinsic interest—stories giving the what, when, why, and how of a new effort to reduce pesticide residues; a new insect control laboratory; a new and tasty dairy product—and can relate these to the "What's in it for me?" of the consumer. City newspapers will use such articles if they're professionally done, well researched and written, supported by interesting, top-quality photographs or drawings, and submitted when they're timely.

Have we made a real effort to get the farm story into the big consumer magazines? Have we tried consistently to get that story used on a broad scale by radio and television stations? Do we seek out and accept opportunities to speak to urban audiences about agriculture? If we do not do so consistently, we should.

If we're to be successful and effective in the long run in communicating with the consumer, we are going to have to do more than talk. We are going to have to create a new image so that the consumer will think positively about agriculture. Too many people think of agriculture as a big pig "slopping" at the government trough. They do not see the cost of agricultural programs as an investment in a necessary industry, but as the expenditure of huge sums of money for the benefit of a few people.

How do we go about creating a new image of agriculture? I believe we need to focus our attention on our organizations to make sure they are responsive to the needs of people. On the other hand, our major effort should be concerned with creating a new image of agriculture rather than a new image of a particular organization.

What kind of image do we want to create? In pondering this question, I thought about the Federal Bureau of Investigation and how J. Edgar Hoover molded the image of this organization in the eyes of the public. When Hoover took over the FBI, it was a politically corrupt and relatively ineffective organization. During his tenure, he created a new image of the FBI. The organization received increased support and recognition during each administration he served. The image of the FBI in the minds of the general public was *the* Public Defender, not *a* public defender. There is a great deal of difference. The organization had several noteworthy characteristics:

1. Solidarity—the FBI spoke with one voice.
2. Accountability—in the eyes of the public, the FBI was untouchable.
3. Progressive outlook—the organization and the methods of apprehending and prosecuting criminals changed with the times.
4. Glamour—the FBI lawman was considered to be lean, tough, and persistent, and always got his man.
5. Dedication—the organization was dedicated to serving the people.

I believe the characteristics I have mentioned are worth considering as we think of changing the image of agriculture. I would like to comment

on each of them in the order listed above.

1. We need to speak with one accord, not as separate groups promoting only our own organizations. Our establishments exist because of agriculture and its importance to the general well-being of the public. Too many times we forget why we exist; we exist to serve, not because of our previous accomplishments.

2. We must account for and use wisely the public resources placed at our disposal, constantly reminding ourselves that we are working for the public and not for our own glory.

3. We must be progressive and ready to redirect our activities according to the needs of the times. Our programs must constantly change to eliminate low priority activities and focus our efforts on areas of research having high priority.

4. We must glamorize agriculture. I believe the scientific community is eminently suited to do this. There is excitement in exploring the unknown, and we need to capitalize on this. We need to acquaint young people with the challenges that exist in our own particular areas of interest.

5. Last, we must be dedicated to serving the people. The general public pays our salaries and furnishes our laboratories, and has a right to expect a payoff from its investment. We cannot afford the luxury of doing research for research's sake, or doing research just because it interests a particular individual. In my opinion, there is no conflict here between basic and applied research because both should be pursued with a payoff in mind. Mission-oriented research often will demand some very basic studies. The balance between fundamental research and applied research will depend upon the particular problem being solved.

In conclusion, if we speak to the consumer directly about the importance of agriculture, if we make sure our organizations are responsive to the consumers' needs, and if we concentrate on building a new image of agriculture, I believe we will establish and maintain effective communications with the consuming public. If we fail, it will have disastrous effects on the agricultural industry. The challenge is ours, and I hope we will accept it.

HOW PUBLIC AND PRIVATE AGENCIES ARE DRAWN TOGETHER THROUGH BETTER PROGRAMS

By Roy L. Lovvorn[1]

The date of August 30–31, 1971, is an important one for cotton research coordination. It was during those 2 days that representatives from the land-grant institutions in the cotton-producing States, the U.S. Department of Agriculture, and Cotton Incorporated met in Dallas, Tex., to explore research needs in cotton and how they might best be met. Two State extension directors also met with us.

With an expenditure in cotton research of nearly $34 million in 1971 between Cotton Incorporated, USDA, and the State agricultural experiment stations, it seemed absolutely necessary that a better mechanism be evolved for coordination. We therefore decided to organize ourselves into a functional, continuing committee to attempt to identify major needs in cotton research and explore ways of achieving these objectives. The Agricultural Research Policy Advisory Committee to the Department of Agriculture and the Land-Grant College Association legitimized our committee by making it a standing subcommittee.

We recognized from the beginning that attention should be devoted toward filling major gaps in our knowledge without interfering with the autonomy of institutions or individuals. The following have been identified as high priority needs:

I. Continuation of boll weevil eradication experiments in Mississippi.

II. A means of lowering the cost of production.

- A. Production.
  - 1. Short season cotton—a systems approach to this problem with emphasis on—
    - (a) Varieties.
    - (b) Obtaining stands.
    - (c) Insects.
    - (d) Diseases and nematodes.
    - (e) Weeds.
    - (f) Water relationships.
  - 2. Harvesting, handling, ginning, and packaging.
    - (a) Harvesting equipment.
    - (b) Handling and storage.
    - (c) Ginning-lint-seed separation.
    - (d) Packaging.
  - 3. Economic analysis of alternative systems.
    - (a) Farm.
    - (b) Marketing.
    - (c) Regional implication.
- B. Farm to mill.
  - 1. Market organization and structure.
    - (a) Alternatives—cooperatives, etc.
    - (b) Improving marketing systems.
    - (c) Economics of scale in ginning.
  - 2. Identify and quantify factors in demand and value for fiber types and qualities.
- C. Utilization.
  - 1. Durable press—higher proportion of cotton in blends.
  - 2. Flame retardance.
  - 3. Knits.
  - 4. More economical spinning of cotton.

Since that time, byssinosis has attracted widespread attention in the industry and has been added to our list of high-priority items. Cotton Incorporated, in particular, is placing great budgetary emphasis on this subject. Likewise, Agricultural Research Service is devoting more attention to it.

A word on procedure seems relevant because we are concerned with a major crop with many

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ıs, grown under a wide variety of condi-
nd sold on a world market with competi-
ɪm synthetic fibers as well as from other
producing countries. Too, we are dealing
xpayers' dollars, both State and Federal,
ıs producer funds from the $1-a-bale pro-

n Incorporated supports most of their
ı through grants and contracts. Their
ion-supported research goes mostly to
ıstitutions, whereas they support utiliza-
earch in both public and private institu-
heir contemplated budget for a particu-
' is reviewed by our committee prior to
'oval by their own board. Staff members
ɪn Incorporated explain their individual
ls after they have been reviewed by com-
nembers in advance of meetings. In the
the Cooperative State Research Service,
oposals for cotton research are likewise
d by the Cotton Coordinating Committee.
'ollowing proposals, which were recom-
for approval on February 5 and 6, 1973,
v been funded:

.ma: Production of mycotoxins of fungi
from cottonseed.

na: Monitoring insect parasites in a cot-
t management program; a predictive
ı forecast changes in density of pink boll-
ɔpulations.

ısas: Cotton pest management: an eval-
f population assessment techniques and
nition of more exact treatment thresh-
h varying cultural diseases of plants.

ɪnia: The biological efficiency of cotton
on systems.

iana: Control of the boll weevil and oth-
ɔests of cotton through the use of host
sistance; effect of subsurface drainage
ɜn content, root development, and cotton
ɔoorly drained Mississippi River alluvial

ısippi: Development of cotton breeding
rying resistance to the two-spotted spid-
Tetranchychus urticae Koch, and to the
d plant bug, etc.; control of bermuda-
ıhnsongrass, and spurred anoda in cot-

Mexico: A study of growth and environ-
'elationships in conventional and short-
ɔtton cultures and the influence of these
ological efficiency of the crop.

Oklahoma: A biological-economic model of insect populations and control in cotton.

South Carolina: Farm and gin community evaluations of machinery complements for harvesting and hauling seed cotton.

Tennessee: Optimizing cotton tillage; basic research on the biology and habits of the boll weevil, *Anthonomus grandis* Boheman, to support a pest management program on cotton in Tennessee.

Texas: Plant resistance to cotton fleahopper and boll weevil; adversity- and multidisease-resistant cottons, *Gossypium hirsutum* L. which are useful to high-density culture and to promoting simplified management.

Texas: Analytical systems models to evaluate alternative pest management policies.

Virginia: Biochemical control of efficiency in the cotton plant.

Boyce Thompson: Characterization of the enzymatic mechanisms of pathogenesis in Verticillium wilt of cotton.

Other members of the committee, both State and Federal, report to us at each meeting on research in progress and plans for the future.

How successful have we been? Although progress is being realized, much remains to be done. We have taken a hard, collective look at the research needs of cotton; identified the major research needs of cotton; examined in considerable detail the research programs now in progress; and gained significantly by associations with each other. Some of the problems still facing the committee are how to achieve joint planning without interfering with the autonomy of institutions or individual investigators; relating to the budgetary constraints that we all face; significantly involving institutions and agencies not represented on the committee; and achieving better communication between members of the committee and scientists actively engaged in cotton research.

The name of the game in this day and age is joint planning. Competition for the research dollar, both public and private, demands that we maximize the returns from the resources we have. Society has every right to expect no less. Our mechanism should enable us to do a better job of allocating resources for cotton research and at the same time help develop models for other commodities.

DELTA COUNCIL ACTIONS IN AGRICULTURAL RESEARCH AND EDUCATION

By B. F. Smith[1]

In discussing the involvement of Delta Council in agricultural research and education, it will be necessary to briefly outline some of the history of our area and of the organization.

The Delta area of Mississippi has been described as beginning in the lobby of the Peabody Hotel in Memphis and ending at Catfish Row in Vicksburg. This locates the Mississippi Delta geographically with a fair degree of accuracy and makes it readily apparent that this area is not located at the mouth of the Mississippi River. It is, therefore, not the true Delta, but a part of the alluvial valley of the Mississippi. Some have said that the Delta area of Mississippi is a state of mind; this also has some validity because native Deltans are seldom satisfied or completely happy away from their native environment for long periods of time.

The Delta begins near the Tennessee line on the north, close to the Mississippi River where the Bluff Hills abruptly end; it extends some 225 miles southward to where the steep bluffs of loess soil begin again at Vicksburg. Between these two points, the Bluff Hills form a huge semicircle, the widest portion measuring about 70 miles. The area includes all or part of 18 counties—approximately 6 million acres, or 23 percent of the entire State. Numerous streams and rivers carry the runoff from large watersheds located in the hills in the north-central portion of the State. Flood control, drainage, and water resources development are of vital importance. Flood problems in the Delta area of Mississippi have been compounded by the fact that the Yazoo River is the sole outlet for storm runoff from all of the interior streams; this river in turn empties into the Mississip near Vicksburg.

The Mississippi River forms the western bc der of the Delta. This great river and its trib taries carry the rainfall runoff from the enti middle of the nation—41 percent of the area the 48 contiguous States.

The Delta is nearly level, with land that slop gently from north to south on an average about one-half foot per mile. It is one of the mo productive agricultural sections in the wor however, its development has been a long, uph fight against floods, the boll weevil, and wee and grass, which grow at fantastic rates. Cu rent land use of the Mississippi Delta cropland, 67 percent; forest lands, 15 perce pasture, 5 percent; other land, 3 percent; a non-agricultural land, including water are urban and federal land, 10 percent. This does n include the land between the levees and the M sissippi River that we call the batture, which heavily wooded containing some of the fin hardwood forests in the world and some t best hunting and fishing areas.

Income from agriculture has always been t basis of the economy of the Delta, and cotton the principal crop. The farmers of the area ha a long history of active interest in agricultu research. Delta farmers were instrumental establishing a branch of the Mississippi Agric tural Experiment Station in the area, purchasi and deeding land at Stoneville which formed t nucleus of the Delta Branch Experiment Stati

Delta Council was organized in the middle the depression in 1935. From its inception it l been vitally concerned and actively involved w agricultural research and education progra The Council, however, is more than a farm o cotton organization and is supported by the ag cultural, business, and professional leaders the 18 Delta and part-Delta counties. Its ini

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program was concerned with agriculture and agricultural research, flood control, and highway development. Today the program of work is still vitally concerned with these same areas of action, but has been expanded to deal with all phases of the area's economy, including industrial and community development.

In 1937, realizing the importance of hardwood production to the area, Delta Council initiated action through the State Legislature which added a 2,600-acre experimental forest to the experiment station property. In the early 1940's, the Council helped to establish a small research unit of the Southern Forest Experiment Station to work in the field of hardwood management research at Stoneville.

In 1938, action initiated by Delta Council resulted in the organization of the National Cotton Council of America. Delta farm leaders have maintained active interest and strong support of the National Cotton Council throughout the years; they advocated cotton farmer contributions of $1 a bale for research and promotion, first through the Cotton Producers Institute and later through Cotton Incorporated.

One of the early committees established by Delta Council was the Advisory Research Committee. Its first chairman was George B. Walker, one of the early superintendents of the Delta Branch Experiment Station and founder of the Stoneville Pedigreed Seed Company. Mr. Walker also served as a member of the Mississippi Senate for many years and was widely recognized for his outstanding leadership.

The objectives of the Advisory Research Committee have remained unchanged. These are to serve in an advisory capacity to research personnel at the Delta Branch Experiment Station, and to work in every way possible to make sure that all of our research agencies have adequate funds and facilities. The Advisory Research Committee has exerted every effort to carry out these objectives, yet it has refrained from interfering with the administration and direction of agricultural research programs.

The Advisory Research Committee initiated a series of national meetings that were held annually over a period of 12 years. These were the Cotton Spinner–Breeder Conferences and represented the first effort to bring cotton spinners, breeders, and farmers together to discuss mutual problems and to work out acceptable solutions. When these meetings were initiated in 1944, there were no descriptive terms for specific cotton fiber quality characteristics other than grade, color, and staple length. Cotton classers and cotton buyers described cotton as having character but were unable to define traits of the fiber that contributed to good character. They knew it was there but didn't know why. Also, cotton spinners talked in terms of spinnability but they, in turn, were equally as vague with regard to the factors that contributed to spinnability. Over the years and with the assistance and leadership of the late Francis L. Gerdes, one of the pioneer cotton technologists and outstanding USDA cotton leaders, the science of cotton technology developed rapidly. As cotton fiber characteristics were identified, defined, and measured, cotton breeders were able to begin building desirable characteristics into their cottons. Textile manuacturers were able to recognize the properties that contributed to spinnability. A whole new language was developed to describe cotton fiber properties, and textile mills invested in well-equipped laboratories to aid in evaluating their raw materials.

The basic natural resource of the Delta is its soils; however, a rather high percentage of Delta soils is heavy clays, known locally as "buckshot" soil. Inherently more fertile than sandy loam, heavy clays are usually characterized by poor internal drainage and have historically posed a difficult problem to Delta farmers. The Delta Branch Experiment Station was handicapped in that it had no buckshot soils on which to carry on long-term research projects. Reacting to this need, the Advisory Research Committee organized the nonprofit Delta Research Foundation, raised sufficient funds for a down payment on approximately 500 acres of buckshot land adjoining the experiment station property, and purchased this land for experiment station use. The title was eventually transferred to the Mississippi Agricultural Experiment Station. Acquisition of this property rounded out the landholdings of the Delta Branch Experiment Station, which now consist of 2,600 acres in the experimental forest and approximately 1,200 acres used for agricultural research purposes. All of this land, except about 175 acres which was purchased by the Federal Government, was made available without cost to the State.

Rapidly changing competition facing Missis-

sippi cottons during the early 1960's posed a serious, immediate, and direct threat to the economy of our state. Results from cotton research efforts in other major cotton-producing areas such as California had a direct effect on the urgent need for an expanded cotton research program in Mississippi. The Advisory Research Committee initiated an appraisal of our cotton research effort by Council leaders and personnel of Mississippi State University and the Delta Branch Experiment Station. Several important facts were revealed. First, the State of Mississippi was making a very modest investment in the cotton research program. Second, an all-out effort should be made to expand our cotton research program to reduce cotton production costs, increase farm income, and meet market competition, at the same time improving and maintaining quality of the cotton produced in our area.

Following this study, a program was developed and presented to the Mississippi Legislature, resulting in the passage of two bills, one of which was a temporary measure to give immediate support through a 15¢/bale tax on cotton for a 2-year period. This support provided a cotton physiology-pathology greenhouse complex, a research engineering shop, alterations to the water and gas distribution and drainage systems, and some badly needed farm, land formation, and basic laboratory equipment.

At the same time, a permanent bill was passed to become effective in 2 years, which permitted counties located in whole or in part within levee districts to withhold 1 mill on the assessed evaluation which was then going to the State, provided that an additional one-quarter mill be levied for research support. The entire amount of 1¼ mills would then be made available to the Delta Branch Experiment Station for agricultural research, with primary emphasis on cotton. This program was presented on an individual basis to each of the County Boards of Supervisors and was approved by all of them. Funds from this source now amount to approximately $500,000 annually.

Following improvements made with the bale tax monies, the second step was to correct research deficiencies in the existing program, including supporting personnel, in the areas of plant breeding and genetics, plant pathology, plant physiology, weed control, and agricultural engineering. The second phase also involved the development of research and laboratory work space, as well as an adequate library. The badly needed cotton laboratory building was completed in early 1967. This was a major step in providing the necessary facilities needed by research personnel to expand and maintain a high-quality research program on cotton. This new building houses several very well-equipped laboratories for cotton pathology, cotton physiology, weed control, and cotton breeding and genetics. One of the best equipped cotton fiber testing laboratories—essential to develop and maintain and improve fiber quality—is now immediately available to plant breeders. Another outstanding feature is the growth chamber that enables basic research on investigating diseases affecting cotton and herbicide translocations. The accessibility of the researcher and his work to the producer has certainly been enhanced by this program. Many thousands of farmers visit the Delta Branch Experiment Station each year to contact research personnel regarding field, greenhouse, and laboratory work on specific production problems.

The library, urgently needed to develop and support research programs at the Delta station, has also been established. There are now over 15,000 research volumes available directly to the scientists. The importance of an adequate library to support agricultural research cannot be overemphasized.

The third phase of the expanded research program was the addition of highly trained scientific personnel.

The major portion of the expanded research program at the Delta Branch Experiment Station has been directed specifically to cotton, as was intended when this program was initiated. In addition, research in vegetable production has been expanded. Soybean research at the Delta station has for some time been under the very capable leadership of E. E. Hartwig, USDA agronomist, known throughout the world for his accomplishments. Additional support has been given to Dr. Hartwig's program, and recently emphasis has been placed on insect resistance in soybean varieties.

Beef cattle research has received major benefits from this expanded program. Finishing beef animals for slaughter looks promising as supplemental income to cotton farming. Expanded

emphasis has been given to finishing beef cattle on feedlots, both conventional and slatted-floor types. Feeding trials are also under way to evaluate the possibility of using gin trash in feed for beef animals, not only as a profitable ingredient for feed, but also to help eliminate the gin trash waste problem.

The Advisory Research Committee of Delta Council has also been active in securing additional federal funds for agricultural research. Hardwood industry leaders working through the Delta Research Foundation have provided supplemental funds for hardwood management research for many years. This industry support, plus hard work by the committee and industry leaders, has resulted in the expansion of the hardwood research program from a three-man staff to the current staff of highly trained scientists and technicians and in the construction of a hardwood laboratory at Stoneville. Efforts also have been consistently centered on helping to provide badly needed funds for cotton ginning research and cotton mechanization.

More recently, efforts resulted in an appropriation of \$3½ million and construction of a five-story U.S. Delta States Agricultural Research Center, dedicated at Stoneville on October 18, 1971. The Mississippi Agricultural Experiment Station provided the land for this new regional facility, which houses three major areas of work—cotton physiology, weed control, and insect control. The cotton physiology laboratory conducts basic research on the cotton plant with the ultimate goal of reducing the cost of production and improving the yield and quality of seed and fiber. Weed research and insect research are focusing on development of bioenvironmental methods for control of insect pests, noxious weeds, and grasses.

Currently this new facility is only partially staffed. We worked very hard last year to have funds appropriated for full staffing; however, as you know, the Agricultural Research Service has been operating under personnel ceilings and these funds have not been available for use.

I have been able to touch only on some of the highlights of Delta Council actions in agricultural research and education. These actions reflect the realization by our members of the great importance of agricultural research to the economic progress of our area and State.

We also work at the State level in helping to obtain annual appropriations for agricultural research and education programs. Delta Council spearheaded efforts to obtain State funds for construction of the boll weevil rearing facility at Mississippi State University, is active in support of the boll weevil eradication research program, and strongly supports the overall agricultural research and education program. We appear before the appropriations committees of the Mississippi House and Senate in support of these programs, and do our utmost to make sure that scientists working in these important fields have the funds and facilities they need.

In closing, I would like to point out that we are very much concerned about the massive cutbacks in Federal support for agricultural research. While we are in wholehearted agreement with the need for economy in government, we believe that someone, somewhere, has made a bad mistake in the appraisal of priorities. It is difficult for us to understand why the Agriculture and Interior Departments are singled out for huge cuts in a Federal budget that adds \$1 million for research and development activities in fiscal 1974.

The ability of U.S. farmers to produce the bountiful supplies of essential foods, fiber, and agricultural raw materials that contribute so much to our high standard of living, making U.S. agriculture the envy of the world, just didn't happen by chance. It is the product of the unique Federal-State relationship in the field of agricultural research and education.

To anyone who has any understanding at all of the international situation and the importance of agriculture to our national economy, it is impossible to understand why such drastic cuts in agricultural programs are being initiated. Agriculture is the only bright spot in our entire dismal balance-of-payments picture. It now appears that we will export approximately \$11 billion worth of agricultural products during this marketing year and there is every indication that this can be increased in the future. The real reason that the Russians and Chinese are making friendly gestures in our direction is because they are desperately short of basic agricultural commodities.

Here on the domestic scene drastic reductions in agricultural programs will be reflected in

higher costs for food, fiber, and other agricultural products. The only way that restraints can be placed on spiraling food costs is through incentives for greater production and the achievement of increased efficiency through research and education programs. We believe that the reductions in Federal support of these programs and the additional reductions planned for the future represent a very grave threat, not only to agriculture, but to the national welfare. Unless some kind of balance in priorities is adopted, the consuming public could wake up some morning to find that many of the agricultural products that they have taken for granted are no longer available.

FACTORS CONTRIBUTING TO INSECT RESISTANCE IN COTTON AND THEIR USE IN A PROGRAM OF PEST MANAGEMENT
(ABSTRACT)

By T. Don Canerday and S. H. Baker[1]

Several genetically controlled characters of the cotton plant have been tested for their value in abatement of cotton insects by a number of researchers. Certain morphological characters have been found to contribute to boll weevil and/or *Heliothis* resistance.

Selected morphological characters of the cotton plant, namely Frego bract, red plant color, okraleaf, nectaries, and leaf pubescence, were evaluated for resistance to the boll weevil and *Heliothis* in field experiments at Tifton, Ga., from 1969 to 1972.

Frego bract and red cottons generally sustained less weevil injury than normal bract and green cottons in mixed plantings. Tightness of the bract roll appeared to be inversely related to efficacy of weevil abatement. No real differences were detected in *Heliothis* oviposition on glabrous or nectariless cottons in small-plot field experiments. Okraleaf and Frego bract cotton did not appear to significantly influence *Heliothis* selection of oviposition sites, and no differences existed in number of larvae or square damage resulting from larvae feeding on untreated okraleaf or Frego bract cotton in small plots. However, *Heliothis* control with insecticides appeared to be enhanced on okraleaf and Frego bract cottons. Weevil abatement with insecticides also appeared to be enhanced on Frego bract, but not on okraleaf cottons. All cottons tested sustained injury above the economic damage level where no insecticides were used.

A genetic breeding stock, 'Georgia Super D', containing redleaf, Frego bract, okraleaf, glabrous, and nectariless characters, was generally the most resistant cotton tested in 1971 and 1972. In an isolated 1-acre block planted to an alternate 8 rows 'Coker 310' × 24 rows 'Super D' pattern, weevil injury was 50 percent less to the 'Super D' cotton, and pesticide use was reduced 40 percent. However, yield of the 'Super D' was substantially lower than 'Coker 310'. This was expected, since it is a raw selection and not an improved strain.

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BOLL WEEVIL ERADICATION EXPERIMENT

(ABSTRACT)

By E. F. Knipling[1]

During the late 1960's pilot plant tests were undertaken to determine if an isolated boll weevil population could be eliminated through use of several integrated suppression methods. The area selected for 2-year experiments consisted of over 20,000 acres of cotton centered in southern Mississippi and extending into Louisiana and Alabama. The central core of approximately 3,000 acres constituted the eradication test area. Buffer zones around the core, ranging in width from about 15 to 25 miles, constitute a general suppression area where insecticides were used to minimize migration of boll weevils into the central core area.

The pilot experiments were designed to test the feasibility of boll weevil eradication and to further develop technology for large-scale operations. The program is a cooperative effort by many Federal, State, and cotton industry institutions, financed by the Agricultural Research Service, Animal and Plant Health Inspection Service, Cooperative State Research Service, and Cotton Incorporated. The boll weevil rearing facility was constructed by Mississippi State University.

Several suppression systems were applied in the core and first buffer areas during the first year. Intensive applications of insecticides to limit reproduction and diapause were made to the core and first buffer zone in the fall, supplemented by defoliants and stalk destruction. The next spring pheromone-baited traps and trap crop plantings were employed to further reduce the boll weevil population. Supplemental insecticide applications were also employed at pinhead square time. The last suppression component consists of sterile male releases.

Tests are now in the second year. Many small cottonfields are surrounded by high trees and other obstacles, making aerial applications of insecticides impracticable. Ground equipment must be used to support aerial insecticide applications. Difficulties were encountered in the mass rearing of boll weevils and in achieving consistent and high sterility levels, much of them associated with equipment failures in the rearing plant. The boll weevil pheromone traps and trap crop plantings performed well, but overwintered populations were still too high the first spring for pheromones and sterile males to have the necessary suppression impact.

An all-out attack was started on the substantially reduced population in the summer of the second year, 1972. In-season insecticide applications were made to prevent buildup of the population until the second fall program was scheduled to start. This program was followed by thorough applications of insecticides by air and ground in the fall of 1972.

The boll weevil population in the core and first buffer zone was reduced to an extremely low level in the fall of 1972. It seems highly probable that the population this spring will average less than one per acre, contrasted with an overwintered population of about 1,000 per acre before the test program began. Sex pheromone traps and pheromone-baited trap plantings will be employed this spring and summer to further reduce the low population, followed by release of approximately 100 sterilized male boll weevils per acre per boll weevil generation during the growing season. Supplemental insecticide applications will be made only if necessary.

Intensive population assessments will be necessary to measure the degree of the program's success, because when boll weevils average less than one per acre, it is very difficult to determine their presence and location. Although populations have been reduced in the two outer buffer zones, substantial numbers are present around the core and first buffer area. Some boll weevils fly in excess of 25 miles; in the coming summer months we must determine if the suppressive measures yet to be applied will be capable of eliminating the already greatly reduced population and if reproduction of any emigrating females can be prevented.

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SHORT-SEASON COTTON RESEARCH

By Levon L. Ray[1]

Much of the cotton production research has centered around adversities of the environment, pests (weeds, insects, and diseases), drought, and high or low temperature. The short-season cotton production system concept fits the plant protection subject well. In many areas and for many reasons, it would be advantageous to reduce the production season—in some areas to escape the devastating effects of insects or disease, in others late season drought, or perhaps to move harvesting into a period of more favorable weather.

The short-season cotton production system, and it is a systems concept, grew out of research begun nearly two decades ago at the Texas Agricultural Experiment Station in Lubbock, Tex., on production of cotton in narrow rows, which generated tremendous interest and considerable controversy across the Cotton Belt. Some have pictured narrow rows as a cure-all for cotton's ills and many believe the simple adoption of this practice will reduce production costs considerably. This is not true. Many other knowledgeable people in the cotton industry look at this concept as a harebrained idea with no potential whatsoever. This view is also incorrect.

Narrow-row cotton production is not new. In fact, broadcast planting (hand sowing) was common in primitive cotton cultures. Today in several foreign countries, row spacings are narrower than those used in the United States. Spasmodically, cotton production in row widths narrower than 3 feet were researched, but only in recent years have we seen a serious and concerted effort to develop a narrow-row culture system.

Active research programs in narrow-row cotton production are found throughout the Cotton Belt, but this presentation will be confined mainly to our program at Texas A&M University Agricultural Research and Extension Center at Lubbock, its development, and some of the concepts and philosophy related to it.

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First, let's clarify the connection between narrow-row and short-season cotton production systems. Since cotton is a continuously fruiting plant, the fruits (bolls) are initiated over a period of time. The length of this period is dependent on the number of fruits per plant; the fewer the number per plant, the shorter the fruiting period. With narrow rows, making possible a greater number of plants per unit land area, the number of bolls per plant can be reduced while maintaining a given yield level. Thus, early crop maturity may be enhanced. Close row spacing and high plant population alone may or may not bring about increased earliness. Narrow rows are even more important in another way to the short-season concept. Strains and varieties which would reduce the production season requirement have been available; however, these were not used and received little attention because their yield was inferior in the conventional row width, although in a narrow row configuration optimum yields could be obtained.

Initially, our concepts in narrow-row cotton production were quite different from those we now have. We conducted our first narrow-row tests in 1954. The basic idea was to see if high fertility and water levels and high plant population would provide a yield breakthrough. Cotton was planted in 7-inch rows, and the high fertility rates did produce exceptionally high yields of approximately three bales per acre. However, it was apparent that the problem of controlling weeds would make such a system impractical for farm use.

Research in the late 1950's centered on row widths which could be cultivated, mostly 20 to 26 inches. Using standard varieties, these row spacings gave an average yield increase of about 10 percent over the conventional 40-inch rows. During this period a very simple harvesting unit for the narrow-row plots was developed by Agricultural Research Service engineers at Lubbock. The unit consisted of a basket with fingers to strip the bolls from the plant. It was attached to a front-end, tractor-mounted loader to propel it through the plots. In 1963 a fully mechanized, self-propelled harvester was constructed. Also

using the finger stripper method of removing the cotton, this machine harvested a swath 108 inches wide. This type of harvester, with the right type of plant, is very efficient. Its simplicity greatly reduces both investment and maintenance costs. The agricultural engineers also worked on the development of planter and weed control equipment. A postemergence herbicide applicator has been developed, which has been used with excellent results, even in the very narrow row spacings.

In the early 1960's, with the availability of more reliable cotton herbicides, attention was turned again to the very narrow rows. We have had many successes controlling weeds in cotton produced in 8- to 12-inch rows. However, it has become apparent that with presently available herbicides, resistant weed species will become an intolerable problem in row spacing configurations that cannot be cultivated. Several narrow-row patterns have been worked out which will permit cultivation.

In the early 1960's, too, we realized that variety adaptation to narrow rows was important, and if optimum success was to be attained with this system of production, a variety must be developed specifically for narrow rows. In 1961 a progeny in our breeding program appeared to have many characteristics which might be advantageous in narrow-row production. This progeny, strain CA 491, was very early maturing with a short plant and small leaves, producing very few or no vegetative branches. This was the first case to my knowledge of a cotton being selected specifically for narrow-row culture.

This strain was included along with two commercial varieties in a row spacing test, the third year of which was concluded in 1965. A highly significant row spacing-variety interaction was found. With experimental strain CA 491, narrow rows yielded 11 percent more than conventional rows; with 'Paymaster 101', an early standard variety, a 6 percent yield increase was obtained; narrow rows decreased the yield of 'Blightmaster', a later maturing variety which tends to produce a large plant, by 7 percent. Later tests have confirmed the variety-row spacing interaction.

In 1964 the Cotton Producers Institute (now Cotton Incorporated) provided financial assistance for a project to investigate means of circumventing the adverse effects of low temperatures. The initial phases of the work centered mainly on physiological aspects of the effects of low temperature, but realizing the potential for a dwarf early variety to escape the devastating late-season low temperatures, our research was increased in this area. We have developed stocks far superior to the original 1961 progeny. Particular attention has been given to fiber quality and Verticillium wilt tolerance in this program. It appeared that fiber quality, particularly length, and wilt tolerance might be limited in these very early maturing types. However, our research has indicated that there are no serious limitations in these respects. We have in them lines with good wilt tolerance and with fiber length very close to that of the 'Acala' varieties.

By the mid-1960's we had made excellent progress in mechanization and variety development for narrow-row cotton production, but we had limited fertility and weed control research, with practically no information on irrigation, insects, or diseases. In 1970 we received a 4-year grant from the Cooperative State Research Service (CSRS) to investigate some of these production problems. The third year's data from comprehensive fertility, irrigation, and variety interaction tests are being analyzed. Briefly, the data indicate that production practices will have to be more coordinated than in conventional systems. For example, the correct fertilization program will depend not only on soil type and residual nutrients, but also on the irrigation management, the variety, and the row spacing.

By manipulating variety, water, and fertilizer, it can be consistently shown that a narrow-row system is inferior to conventional production systems. A tall, limby variety with large leaves in a very high plant population with ample water and fertilization will produce excessive vegetative growth. Crop maturity will be delayed instead of hastened, and yields drastically reduced. A very unsatisfactory harvesting situation also results. The excessive stalk and limb material makes it difficult to remove the bolls from the plant, and the trash content of the harvested cotton will adversely affect fiber quality. On the other hand, the early maturing, short plant types grown in narrow rows can produce a high-yielding crop ideally suited to once-over mechanical harvesting.

Narrow-row production provides opportunities to greatly reduce harvesting costs and improve harvesting efficiency. If we are to use a

once-over harvest system, without which maximum cost reduction will not be achieved, the crop must mature (bolls open) over a relatively short period of time. The short-season concept provides for this in that the bolls are set in a comparatively short time.

Narrow-row production decreases the loss from Verticillium wilt, one of the most severe diseases of cotton. No advantage or disadvantage has been noted in respect to other diseases. The data available at this time are not sufficient to properly evaluate the effects of the system on insect populations or damage.

Producers are beginning to try this system. Harvesters are available, and this year, for the first time, two varieties developed specifically and recommended only for narrow-row production will be marketed. In general, growers were successful, and it is anticipated that the acreage will expand.

Many organizations have had a part in the development of the short-season cotton research program at Lubbock. In addition to State and Federal (including CSRS) funds, assistance has come from the local producer organization, Plains Cotton Growers, and the national producer group, Cotton Incorporated. Machinery, chemical, and seed companies have made contributions also. The importance of this broad-base support was much more than simple funding of the research. It directly involved groups whose interests were essential for its success.

At the local level many persons from the experiment station and U.S. Department of Agriculture, representing several disciplines, were involved in the research program, individually and cooperatively. Engineers, plant physiologists, pathologists, entomologists, and agronomists in soils, water, and plant breeding have participated. Similar cooperation has not been previously experienced throughout the Cotton Belt. The benefit from the togetherness of the disciplines demonstrated in this research could well be worth the costs.

More direct benefits will be realized. For at least some areas, such as the northern part of the Texas High Plains, the short-season production system (narrow rows and early varieties) will improve cotton production efficiency tremendously. Other areas will be benefited, but to a lesser extent. For some areas its merits remain to be proved, but there seems to be some potential for almost any cotton producing area.

Unsolved problems still exist, but many avenues are open for improvement in varieties, machinery, and management systems, making this still a very fertile area for productive research.

COTTON WEED CONTROL RESEARCH

By Ralph S. Baker[1]

This discussion covers various aspects of our cotton weed control research at Stoneville, carried out by agronomists, plant physiologists, and agricultural engineers.

GOOD STAND OF COTTON NEEDED

We strive to get a good uniform stand of healthy, rapidly growing cotton on smooth beds. Controlling weeds is vastly complicated where the cotton stand has skips, and height varies greatly. If cotton growth is slow, there is less height differential between cotton and weeds, making it more difficult to use directed herbicide sprays. Cultural practices that assure a good stand of cotton are necessary for the most effective control.

Although weather conditions often determine the final stand, seed quality and seeding rate are variables that deserve careful consideration. Research has shown that seed treatments and the level of seed in planter boxes can greatly alter seeding rates. Treatments on mechanically delinted seed make a significant difference in seeding rates, but the level of seed in the planter boxes has a much greater effect. The highest rate of seeding occurred with no seed treatment. As chemicals were added directly to the seed and through planter box treatments, the seeding rate was reduced as much as 16 percent. With planter boxes loaded to 50 and 20 percent of capacity, the seeding rates were reduced 17 and 34 percent, respectively, as compared to the rate with full planter boxes. Thus, the planting rate was highest when the planter boxes were filled to the top with seed.

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PESTICIDE INTERACTION

With several insecticides being applied on the cottonseed or in the soil at the time of planting, the possibility exists for deleterious interactions among the various chemicals. This was shown several years ago in Texas with combinations of systemic insecticides and urea' herbicides. In Louisiana, cotton was shown to be more susceptible to seedling disease where trifluralin was incorporated into the soil. Research at Stoneville has shown pesticide rates, soil properties, and weather conditions to be critical factors. Using recommended rates under field conditions, it has been difficult to show deleterious pesticide interactions. Soil properties which increase the likelihood of deleterious interactions include light texture, low organic matter, and low pH or acid subsoil. One of the main findings has been the importance of using a fungicide. Regardless of the herbicide treatment, an insecticide used at planting often reduced the stand, but if a fungicide was used in combination with the insecticide, then the stand was not reduced significantly.

SOIL-INCORPORATED HERBICIDES

Soil-incorporated herbicides such as trifluralin and nitralin have meant a lot to cotton farmers because of the increased consistency of grass control, regardless of weather conditions. There are now at least five products in this dinitroaniline family of herbicides that are under development. Research indicates that these new products control a similar range of weed species, although the rate required varies with the herbicide. Profluralin and A–820 appear to have a greater margin of selectivity on cotton than nitralin or tri-

fluralin. This may permit the use of high rates for a couple of years to obtain control of rhizome johnson grass. Such a practice is now used very successfully with trifluralin in soybeans. The safety of this practice on cotton has not yet been established.

SHIFTING WEED SPECIES

A shift in cultural practices has occurred during the past 5 to 8 years. Soil-incorporated herbicides have been broadcast to get better grass control. Hand hoeing has nearly passed out of the scene, and cultivation has been reduced. During this period, prickly sida has become a severe weed problem. We will very likely encounter other shifts in weed species which bring changing weed problems. The Europeans are probably ahead of us in understanding the dynamic change in plant populations. They have developed a discipline called plant sociology. Our cottonfields are pretty specialized situations, but we do not eliminate the laws of nature.

Research has shown satisfactory control of prickly sida on most soils using fluometuron preemergence followed by timely postemergence applications. A mixture of MSMA with either fluometuron, prometryne, or diuron is effective if applied before prickly sida is 2 inches tall. Linuron also controls prickly sida, but is not labeled for use until cotton is 15 inches tall.

Full-season competition at infestations of 4 and 12 prickly sida plants per foot of row reduced yields of cotton by 18 and 37 percent, respectively, compared to a weed-free check. Weed competition early in the season is most critical with respect to the yield of cotton. If cotton is maintained weed-free during the first 8 weeks after planting, yields are seldom reduced by prickly sida competition developing later in the season. During the first 4 weeks after emergence, prickly sida did not grow as rapidly as cotton. Six to ten weeks after emergence, cotton and prickly sida were about the same height. Nineteen weeks after emergence, some prickly sida plants were 6 to 12 inches taller than cotton.

Other weeds that are becoming more of a problem in cotton include spotted spurge, *Euphorbia maculata* L.; velvetleaf, *Abutilon theophrasti* Medic.; and spurred anoda, *Anoda cristata* (L.) Schlecht. Spurred anoda poses a serious threat. Like prickly sida, it is closely related botanically to cotton, but it is much more competitive than prickly sida. Field research in 1972 using five herbicides preemergence for controlling anoda in cotton showed norflurazone as the most effective, followed by fluometuron. The order of effectiveness was reversed with respect to prickly sida.

NEW HERBICIDES

Several new herbicides are being evaluated for controlling weeds in cotton. Norflurazone has been mentioned for its preemergence activity on broadleaf weeds. It is also very effective on grasses and shows some activity on nutsedge. Another herbicide with preemergence activity on nutsedge is MBR 8251. Methazole is effective preemergence on a broad range of weed species, and is effective postemergence on many broadleaf weeds, including prickly sida. Glyphosate is the latest development to come on the scene. It is active only when used postemergence and leaves no soil residue. Glyphosate offers exciting possibilities because it controls not only annual weeds, but a broad spectrum of hard-to-kill perennial weeds such as rhizome johnsongrass, nutsedge, and trumpetcreeper. One limitation of glyphosate is its narrow margin of selectivity on cotton. Research is underway using inorganic salts and surfactant additives under controlled conditions of temperature and moisture in an effort to increase both the activity on weeds and the selectivity on cotton.

Public concern over the use of pesticides and the upward spiral in costs for registration of new herbicides make it more difficult for chemical companies to develop new herbicides. It is a tribute to the agricultural chemical industry that we have so many candidate herbicides to evaluate in trying to solve our changing weed problem.

WATER SHIELD FLAME

A development which originated in Arkansas is water shield flame. Liquefied petroleum gas has been used as fuel to kill weeds in cotton for nearly 30 years. By adding a water shield between the flame and the cotton, the heat in the cotton foliage is reduced without adversely affecting weed control. The water shield is obtained by setting a fan-type spray nozzle

immediately above the burner and parallel to it, delivering 8 to 10 gallons of water per acre. Addition of the water shield permits flaming 5- to 6-inch cotton, compared to the usual height of about 10 inches for conventional flame.

WEED CONTROL IN NONCONVENTIONAL ROWS

During recent years many new spacings have been tried in the search for ways of reducing the costs of producing cotton. These range from twin rows planted about 7 inches apart on 40-inch centers for harvesting with a conventional picker, to aerial-seeded cotton harvested with a cotton combine in a once-over operation. Where plant spacing does not permit cultivation, weed control is dependent on herbicides. In general, total dependence on chemical weed control has led to weed problems after two seasons even under the best of conditions. Therefore, with a cotton production system which does not permit cultivation and with the present herbicide technology, it appears desirable to rotate to relatively weed-free land after 2 or 3 years.

SUMMARY

The cultural, mechanical, and chemical practices currently available for controlling weeds in cotton have enabled producers to control most species quite effectively. The new herbicides now being researched offer exciting possibilities for extending control beyond what has been attained and for meeting the challenge of shifting weed species as they arise.

THE ROLE OF DISEASE IN COTTON RESEARCH

By J. A. Pinckard[1]

During the past 20 years the cultivation of cotton has been reasonably well stabilized. Our disease research has been designed to fit into this pattern of production. In other words, our disease control procedures have followed and have been coordinated with accepted agronomic procedures. We have leaned very heavily—perhaps too heavily—on chemical methods of disease control and on breeding for disease resistance. We recognize chemical methods of disease control as temporary stopgap methods to get us by until more permanent control procedures can be devised, or until breeding for resistance can improve our position. This has been the accepted philosophy of cotton disease control, and it has been reasonably successful during the recent stabilized period of cotton production.

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If we examine the cotton disease loss estimates for the past 20 years (and we have excellent records on a State-by-State basis), we will find the average total losses to be about 14 percent of the crop, representing nearly 2 million bales annually (table 1). However, as I interpret the data and relate it to my previous experience, I would say that cotton disease losses have increased steadily over the past 20 years.

The loss increase seems to be associated with seedling blights, boll rots, Verticillium wilt, root knot, and some new diseases not heretofore well known. The latter have come forward because of our agronomic practices.

In 1936 the Office of Experiment Stations, through the efforts of Howard P. Barss and others, helped organize the Cotton Disease Council. This group of beltwide cotton pathologists has met each year, except for the war years, and has discussed the national and regional problems of

TABLE 1.—*Summary of estimated destruction in yield caused by the major cotton diseases in the United States, 1952–72*[1]

Disease	1952–58 (%)	1959–63 (%)	1964–68 (%)	1969–72 (%)	Average (%)
Seedling blights	2.69	2.67	3.41	3.33	3.02
Boll rots	1.73	2.40	2.42	3.78	2.58
Verticillium wilt	1.49	2.22	3.37	2.47	2.38
Root knot	1.24	1.61	1.72	2.50	1.76
Bacterial blight	1.59	1.81	.79	1.35	1.38
Root rot	.84	1.80	.75	.81	1.05
Fusarium wilt	1.14	1.08	.78	.90	.97
Other	.46	1.52	.45	.98	.85
Total loss	[2]11.19	[3]14.97	[4]13.73	[5]16.16	[6]14.01

[1] Data compiled from Proceedings, Cotton Disease Council, published by Plant Disease Reporter.
[2] 11.19% = 1,706,000 bales.
[3] 14.97% = 2,659,000 bales.
[4] 13.73% = 1,692,000 bales.
[5] 16.16% = 1,773,000 bales.
[6] 14.01% = 1,957,000,000 bales.

cotton pathology. They have estimated and published cotton disease losses by States, as summarized in table 1.

The Cotton Disease Council deserves a word of congratulation for having served the cotton industry well and for having remained viable and useful over the past 37 years. The Cotton Disease Council has no constitution, no bylaws, and no dues. There are only two officers, the chairman and secretary, and several committees. The proceedings, now published by the National Cotton Council in "Proceedings of the Beltwide Cotton Production Research Conferences," outline the history of cotton pathology in the United States almost community by community since 1936. It has been one of the most useful groups of technical people in cotton production.

The cooperative efforts of the members of the Cotton Disease Council have brought under control one of the most destructive diseases of the cotton plant on the North American Continent, the anthracnose disease caused by *Colletotrichum gossypii*. This disease caused losses of 50 to 60 percent regularly until it was discovered by H. W. Barre about 1913–15 that it could be reduced by using disease-free seed. It was not until the early 1940's, however, that it was further discovered that certain volatile organic mercury seed dressings could be used to disinfect planting seed. The use of the alkyl mercury seed dressings became nearly universal, and this disease is now rare except in certain communities where modern methods of culture have not penetrated, i.e., Central America.

The anthracnose disease is still present in the U.S. Cotton Belt, however, and because environmentalists have caused legislation to be written forbidding the use of the mercury seed dressings on cottonseed, I personally expect anthracnose disease to reappear. And if it becomes as devastating today as the early records so indicate, the cost of cotton production will increase sharply. Inasmuch as anthracnose attacks the boll as well as the seedling, and our present practice of cultivating dense cotton growth is very favorable for disease development, our current situation may result in forcing a change in production methods. While we have developed substitute seed dressings to replace the mercurys for control of seed rot, none of our substitutes has been tested against anthracnose. If one or more of these substitutes should prove effective against anthracnose, it will be a fortunate accident!

A certain proportion of our cotton disease budget could be profitably earmarked for a study of how to remove micro-organisms from both the interior and exterior of cottonseed. A successful method would assure control of anthracnose, and would also reduce losses from other disease producing agents, possibly including *Aspergillus* species, the cause of aflatoxin in cottonseed products.

Another one of our difficult and costly production problems is the result of a group of fungi and bacteria causing boll rot. These organisms are normal inhabitants of the soil. In an attempt to produce more cotton lint and seed per acre, the grower usually applies more fertilizer and sometimes irrigation water. The resulting rank growth creates shade around the base of the plants and increases the relative humidity. Almost any fungus present under these conditions is able to rot the boll when the sutures split to expel the lint. Several fungi such as *Rhizoctonia solani, Diplodia gossypina, Phytophthora parasitica*, and species of *Alternaria* and *Fusarium* are common boll-rotting fungi.

Entry into the boll is by direct penetration or by way of stomata which open progressively and remain open as the boll matures. The dense canopy of vegetation, shade, and a high moisture level around the base of the plants result in almost complete loss of the lower bolls—the heaviest and most desirable fruit produced. Attempts to protect this fruit with fungicidal sprays have not been economically practical.

One approach to relieving the shade and humidity problem of present-day commercial varieties would be to develop the so-called okra-leaf types. This approach to boll rot control was proposed by the writer in a presentation before the Cotton Production and Mechanization Conference, Memphis, Tenn., in 1964. Jack Jones, Louisiana State University Agronomy Department, has made substantial progress in this area.

Attempts to reduce boll rot losses by manipulating cultural practices such as skip-row planting, adjustment of fertilizer rates, and plant populations have provided interesting information, but control of boll rot was not achieved even though it was improved. Success depended on the weather. In 1963, for example, very little humid weather occurred during August and September. The average yield for Louisiana in that year was

628 pounds of lint per acre, with an estimated 1 percent loss from boll rots. In 1964 the average yield was 549 pounds of lint, and the actual statewide loss was 12.5 percent in yield. Because both seasons were very similar, except for excessively humid weather during September and October, boll rot was the determining factor of yield. Average State yields do not reflect loss of lint and seed quality, which is very substantial in severe boll rot years. Our boll rot survey of 20 leading cotton-producing parishes showed a loss of 30 percent in 1964.

We have found some of our commercial varieties of cotton bolls to be very resistant to rot between the ages of about 12 and 22 days after bloom. During this age period, waxes, cutin acids, and cuticle thickness are at maximum levels. Fractions of the cuticle, particularly the ethanol-soluble fraction, were found to be fungistatic to several common boll-rotting fungi. One of our more boll rot resistant varieties, 'Deltapine 16', was found to have more boll surface wax ($30.00\ \mu g/cm^2$) than other commercial varieties tested. 'Dixie King II' had the least ($12.09\ \mu g/cm^2$).

As a result of these studies we believe it wise to continue our research for biochemical evidence of boll rot resistance and the genetic transfer of such resistance. Additionally, we have found the bract of the boll to be a contributing factor to disease development. Fungi of several kinds enter the young bracts and remain in the mesophyll tissue until the bract approaches maturity (about the time the sutures split). At this time the fungi emerge to the bract surface and fruit. An abundance of inoculum is therefore produced around the boll at the proper time for easy boll invasion.

From the information we now have we believe it wise to search for genetic material having reduced bracts, or bracts of a tough or distorted morphology resistant to fungal growth. By combining the okraleaf type, the Frego bract, or distorted bract type with high-cuticle thickness and high-wax types, we may be able to improve on boll rot resistance. This will be more likely if we can also identify the biochemical basis of resistance we know is present in the cuticle of 'Deltapine 16'. The only way these problems can be solved is through continued, unbroken public support of research over long periods of time.

I believe it is well to pause and remember that life on this earth, as we know it, would extend but a few weeks if all green plants were suddenly destroyed. Mass settlement of countries, in some cases, resulted from disastrous losses of food crops during the Middle Ages. Man now utilizes in a day about as much energy as is fixed by all terrestrial vegetation in the same time, and the energy requirements of society will soon exceed the total available; therefore, we must give very serious thought to conserving it.[2]

I cannot help but devote some thought to the energy requirements for the production of raw food and fiber. The cotton plant, being one of nature's most beneficial gifts to man, converts solar energy into products suitable for food and clothing. This commonplace energy conversion is accomplished with no drain on fossil fuels and no pollution of the air. What synthetic fiber can claim these virtues?

[2] Harrison, G. A., and Boyce, A. J. (eds.). 1972. The structure of human populations. 448 pp. Oxford University Press, New York.

INFLUENCE OF SOME FIELD CONDITIONS ON THE OCCURRENCE OF AFLATOXINS IN COTTONSEEDS AT HARVEST

By Paul B. Marsh and Marion E. Simpson[1]

INTRODUCTION

In most parts of the U.S. Cotton Belt, aflatoxin contamination of cottonseeds at harvest has been observed infrequently, if present at all (*21*).[2] The aflatoxin-producing *Aspergillus flavus* only rarely infects the seeds in the field in these areas, even though infection with other fungi is relatively common (*36*). In samples from certain limited areas of cotton production, on the other hand, little difficulty is encountered in finding *Aspergillus flavus* infections in the seeds. This is particularly true if we look especially at seeds selected for the presence of a bright, greenish-yellow fluorescence in their fiber or seed fuzz (*36*). The fluorescence has been termed the "BGY" fluorescence because of its bright, greenish-yellow color, and we have recognized this since 1955 as a characteristic symptom of a boll rot caused by *Aspergillus flavus* (*18*).

Evidence has indicated that the presence of aflatoxins in cottonseeds at harvest is closely associated with *Aspergillus flavus* boll rot (*21, 22*). Relevance to the cottonseed-aflatoxin problem, therefore, is involved in the question of where this boll rot occurs geographically and what causes it to occur where it does. Information identifying the areas where the boll rot is present has been provided by a series of surveys of the U.S. crop. Reasons why the boll rot occurs just where it does, however, have not been well established. Following a brief review of background, our major concern here will be with this subject, i.e., why *Aspergillus flavus* boll rot is geographically localized. Numerous literature references to the cottonseed-aflatoxin problem were cited in a recent paper (*21*), many of which are not cited again here.

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[2] Italic numbers in parentheses refer to items in "Literature Cited" at the end of this paper.

RELATIONSHIP OF AFLATOXIN CONTAMINATION AT HARVEST TO *ASPERGILLUS FLAVUS* BOLL ROT

A relationship has been shown between spots with the BGY fluorescence in raw cotton fiber and three other phenomena: *Aspergillus flavus* infection of the fluorescing fiber (*18, 33, 38*), *Aspergillus flavus* infection of the seeds to which the fiber is attached (*36*), and the presence of aflatoxins in the same seeds (*21, 22*). A simple linear representation indicates not only the existence of these interrelationships, but also the degree of closeness of the association between the BGY fluorescence and the other variables (fig. 1).

In our experience, the BGY fluorescence in a fiber is accompanied very regularly by *Aspergillus flavus* infection in the same fiber. This is a very close association. We reported in 1955 that tufts of fiber with the BGY fluorescence in them, taken from field samples, were almost invariably infected with *Aspergillus flavus*, also that the fluorescing pigment in such fiber regularly exhibited R_f's on a chromatogram which matched the R_f's obtained with pigment from

BGY-fluorescence in the fiber — Aspergillus flavus infection in the fiber — Aspergillus flavus infection in the seeds — Aflatoxins in the seeds

FIGURE 1.—Relation of BGY-fluorescing spots in raw cotton fiber to three other phenomena in the fiber and seeds.

fiber incubated in pure culture with *Aspergillus flavus* (*18*). Subsequently, wisps of BGY-fluorescing fiber have been taken from many field samples in other locations and crop years and have similarly shown a very high incidence of infection with *Aspergillus flavus* (*33, 38*). The level of infection with the same fungus in tufts of non-BGY-fluorescing fiber from samples without the fluorescing spots has been very much lower (*34*).

No reason is known to us to lead to the expectation that a growth of *Aspergillus flavus* in a particular cotton fiber and production of the BGY fluorescence there would necessarily always be accompanied by growth of the same fungus into the seed to which the fiber is attached, nor that if the fungus did grow into the seed, it would necessarily produce aflatoxins there in all cases. Actual observations indicate, however, that the BGY fluorescence in the fiber is very frequently accompanied in field samples not only by *Aspergillus flavus* infections in the fiber but also by both *Aspergillus flavus* infection in the seeds (*36*) and aflatoxins in the seeds (*21, 22*). The level of aflatoxins in such individual seeds is often very high (*21, 22*). With field-collected samples whose fiber does not display the BGY fluorescence, the frequency of *Aspergillus flavus* infection in the fiber is much lower, the frequency of *Aspergillus flavus* infection in the seeds is extremely low (*36*), and aflatoxins strongly tend to be absent from the seeds or present only at low average levels (*21, 22*). The discovery that the BGY-fluorescing pigment in cotton fiber is produced from kojic acid (*23*) was hardly unexpected, since this organic acid is well known as a characteristic metabolite of *Aspergillus flavus*.

LOCATIONS OF OCCURRENCE OF *ASPERGILLUS FLAVUS* BOLL ROT

A survey across the Cotton Belt of commercial cotton fiber to locate sources of BGY-fluorescing spots, thus identifying locations of occurrence of the *Aspergillus flavus* boll rot, was conducted on the U.S. crop of 1957 (*26*). This was followed by surveys of the crops of 1966 (*20*), 1967 (*20*), 1969 (*38*), 1970 (*33, 39*), and 1971 (*24*). A general conclusion from these surveys is that *Aspergillus flavus* boll rot was rare in most U.S. cotton-growing areas but occurred regularly in the Imperial Valley of California, frequently in Arizona, and fairly commonly, although usually at lower levels, in southern and central parts of Texas.

POSSIBLE REASONS FOR GEOGRAPHIC LOCATION OF *ASPERGILLUS FLAVUS* BOLL ROT

Evidence is available to support the belief that adaptation of *Aspergillus flavus* to growth in relatively hot, dry circumstances has an important bearing on the localization of *Aspergillus flavus* boll rot. In the hot, dry environment of the Imperial Valley, damage to bolls by the pink bollworm also favors boll infection, not a surprising result since *Aspergillus flavus* is a "wound parasite," i.e., an organism that does not penetrate plant tissues readily except after wounding.

High Field Temperatures and Semithermophilic Nature of *Aspergillus flavus*

In a survey of the crop of 1957 for *Aspergillus flavus* boll rot (*26*), we noted that "the two areas where BGY incidence was high are ones of exceptionally high temperatures at the time when cotton bolls are opening." Those two areas were the Imperial Valley of California and the Harlingen area in the southernmost part of Texas. For the 1970 crop, data on incidence of BGY spots and field temperatures have been provided recently (*21*) and may be seen here also in figures 2 and 3. In the meantime, Halisky,

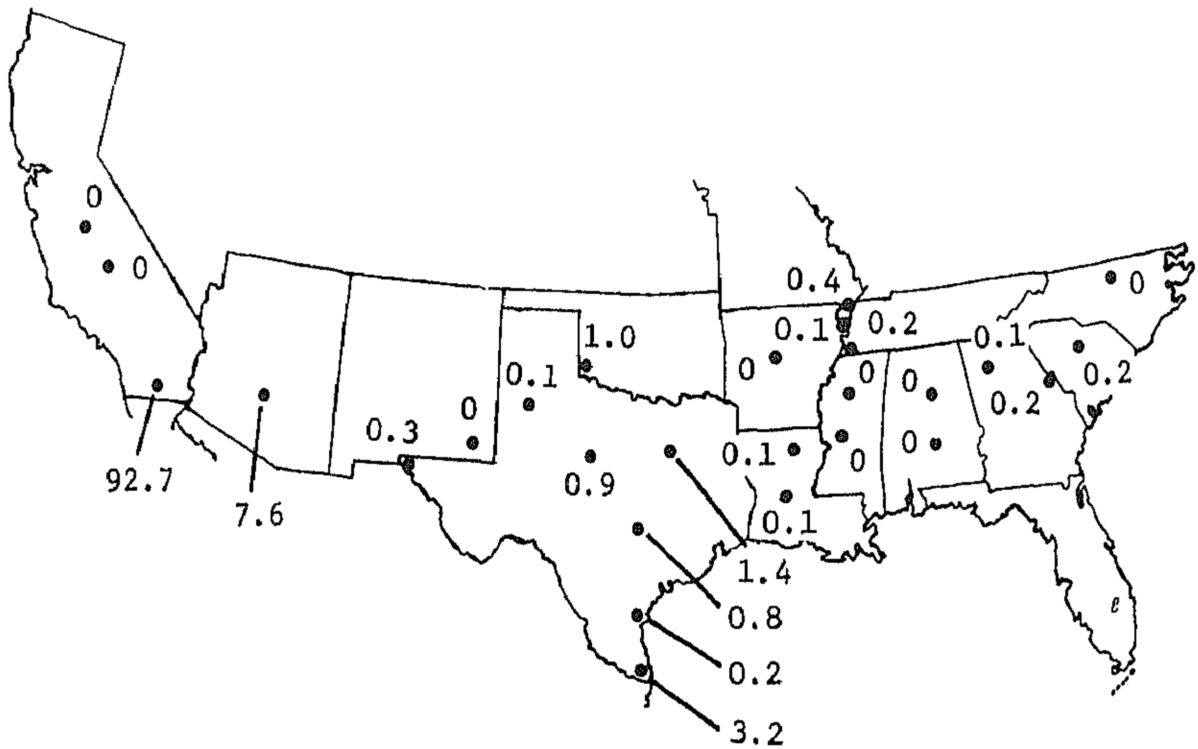

FIGURE 2.—Average number of BGY spots per sample for commercial fiber samples examined from the crop of 1970.

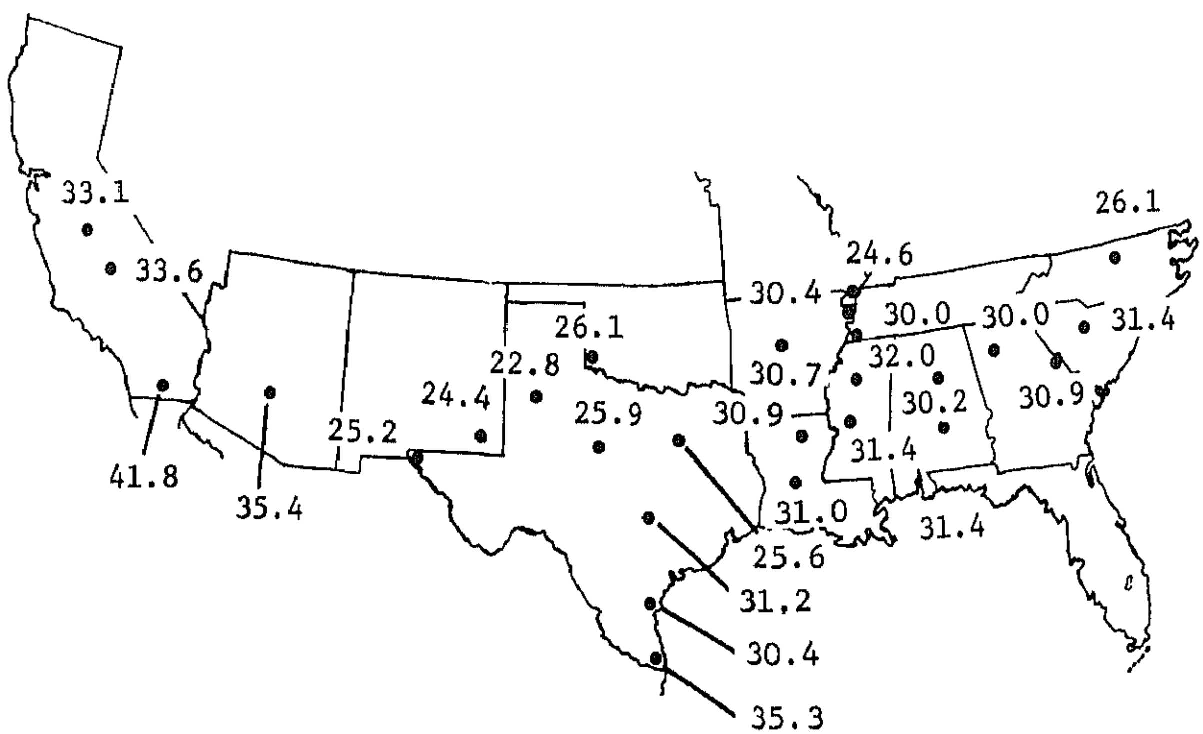

FIGURE 3.—Average daily maximum temperature (° C) during the boll opening period in 1970 for locations corresponding to those in figure 2.

Schnathorst, and Shagrun, working in California, remarked on the probable importance of temperature differences on the presence of *Aspergillus flavus* boll rot in the hot Imperial Valley and its virtual absence in the somewhat cooler San Joaquin Valley of their State (*12*). They pointed out that not only *Aspergillus flavus*, but also *Aspergillus niger* and *Rhizopus stolonifer*, are common as causes of boll rots in the Imperial Valley, and that all three of these fungi exhibited unusually high temperature optima for growth when incubated on cotton bolls in their laboratory.

Our results in growing *Aspergillus flavus* and other cotton boll rot fungi on cotton bolls at different temperatures in the laboratory (table 1) agree with the results of Halisky et al. (*12*). The several boll rot fungi used in our tests were isolated from cotton fiber and seeds and were grown in pure culture on bolls resting on a layer of glass beads over a shallow layer of water in the bottom of a deep petri dish. Isolates of *Aspergillus flavus*, *Aspergillus niger*, and *Rhizopus stolonifer* all grew vigorously and sporulated well at 40° C, whereas the other fungi failed to grow or grew poorly at that temperature or even at 35° C. The conclusion that *Aspergillus flavus* can grow well at fairly high temperatures agrees with prior conclusions in two other laboratories. Diener and Davis (*7*) observed sporulation by *Aspergillus flavus* in culture on peanuts at 43° C, and growth but no sporulation at 46° C. Schindler et al. (*30*) reported heavy growth at 40° C on a wort medium. The fact that at least some isolates of *Rhizopus* can grow and sporulate at rather high temperatures has also been reported previously (*43*). For fungi that exhibit continued growth at 40° C, we would like to coin the term "semithermophile," as distinct from "thermophile," which is used for organisms that will grow at 50° C.

High temperature may also increase the occurrence of *Aspergillus flavus* boll rot by impairing the natural defenses of the cotton tissue to invasion by the fungus. The effect is presumably not entirely specific for *Aspergillus flavus* in the sense that high temperature could also facilitate rotting of bolls by other fungi able to grow at

TABLE 1.—*Effect of incubation temperature on the amount of visible growth of various boll rot fungi in pure culture on cotton bolls*

Fungus and isolate number	Relative amount of visible growth[1]			
	25° C (77° F)	30° C (86° F)	35° C (95° F)	40° C (104° F)
Alternaria sp. #2	4	4	1	0
Alternaria sp. #11	4	4	2	0
Alternaria 71–4	4	4	2	0
Alternaria 71–10	4	4	1	0
Aspergillus flavus 277	4	4	4	3
Aspergillus flavus 248	4	4	4	4
Aspergillus flavus 2999	4	4	4	4
Aspergillus niger 404	4	4	4	4
Cephalosporium 71–12	4	4	2	0
Cladosporium 71–13	4	4	1	0
Diplodia 71–18	4	4	4	1
Diplodia 71–19	4	4	4	1
Diplodia 71–20	4	4	4	0
Fusarium #6	4	4	1	0
Fusarium #361	4	4	1	0
Fusarium 71–2	4	4	1	0
Fusarium 71–3	4	4	1	0
Fusarium 71–7	4	4	2	0
Fusarium 71–8	4	4	0	0
Fusarium 71–9	4	4	1	0
Rhizopus #344	4	4	4	4
Rhizopus 71–15	4	4	4	4
Rhizopus 71–16	4	4	4	4

[1] Rating for relative amounts of visible growth: 0, little or none; 1, slight; 2, moderate; 3, moderately heavy; 4, heavy.

high temperatures. We heated greenhouse-grown cotton bolls in moist chambers over water to temperatures that were somewhat elevated but not high enough to cause immediate visible tissue damage. This was then followed by inoculation and incubation at 30° C on glass beads over water in deep petri dishes used as moist chambers. As may be seen in tables 2 and 3, the pretreatment to elevated temperatures resulted in a more rapid growth and sporulation on the bolls later at 30° C. The temperatures used in the pretreatment were selected with the knowledge that internal temperatures of cotton bolls in sunlight exposure are known to be materially higher than air temperatures (*1*).

Low Moisture in the Field and the Semixerophytic Nature of *Aspergillus flavus*

Many fungus-caused plant diseases that are prevalent in more humid parts of the United States are rare or absent in the Southwest because of the much drier climate there. Numerous examples of this point are made by Streets (*40*). Some of the fungi that cause plant diseases in the Southwest are known to be especially adapted to dry conditions. Streets writes, for example: "The fungi best adapted to our warm dry conditions are the powdery mildews." Weinhold (*44*), generalizing from much data of other workers (*11*), writes: "Powdery mildew fungi are unique: they thrive under dry conditions and the conidia of most species do not require free moisture for germination." In his statement about the powdery mildews, Weinhold was understandably excluding the aspergilli from consideration, because most of these fungi are not common plant pathogens. Many of them are, however, well known for their xerophytic habits, and some of them do infect living plants in the field.

TABLE 2.—*Effect of prior exposure of cotton bolls to moist heat on rapidity of sporulation of* Aspergillus flavus[1]

Age of bolls (days)	No. days to sporulation on carpel walls	
	Preheated	Not preheated
48	3	5
43	2	5
38	2	5
26	2	24

[1] Treated at 50° C (122° F) for 6 h. Bolls subsequently incubated at 30° C (86° F).

Aspergillus flavus may perhaps be reasonably called a semixerophyte. In the experiments of Galloway (*9*), its spores germinated in an atmosphere of 85 percent relative humidity, thus requiring a higher humidity than members of the *Aspergillus glaucus* and *Aspergillus versicolor* groups, but lower than that required by some other forms. For comparison, one should note that many other fungi, including plant pathogens, require free water for germination of their spores (*6, 11*). In the experiments of Koehler (*14*), *Aspergillus flavus* grew on shelled grain of corn at 18.3 percent moisture, thus requiring more moisture for growth than *Aspergillus glaucus* or *Aspergillus versicolor*, but less than several other fungi. Qasem and Christensen (*28*) recorded kindred results from similar experiments with corn. Chen and Griffin (*5*) and Diener and Davis (*8*) also concluded from their investigations that *Aspergillus flavus* is adapted to growth under relatively dry conditions.

The plausibility of our argument about dry field conditions as a determinant of the geographical distribution of *Aspergillus flavus* boll rot may perhaps be increased by examination of related information for other cotton boll rots. *Colletotrichum gossypii* causes a boll rot that is clearly limited to the more humid eastern half of the U.S. Cotton Belt and to other cotton-growing areas of the world that have moderate to high rainfall, as shown in figure 4 (*19, 34, 35*). The fungus produces spores borne in a mucilagenous matrix, and these spores require dew or rain for their dispersal. *Diplodia gossypina* is also reported as a major cause of cotton boll rot in the humid eastern (*19, 25*) and midsouthern (*27*) growing areas of the U.S. Cotton Belt, but occurs only rarely in the drier and more western areas (*12, 29, 31*). The same fungus also infects many other plants (*42*). Two recent papers dealing with the dispersal of *Diplodia* spores from the woody parts of infected citrus (*4*) and pine (*3*) plants show clearly that rain is required for the fruiting bodies to shed their spores. Free water appears to be needed to allow the swelling of the spores that forces them out of the pycnidium or fruiting body in the spores dispersal process.

By contrast, *Aspergillus niger* and *Rhizopus stolonifer*, two fungi that frequently accompany *Aspergillus flavus* as causes of boll rot in the

Imperial Valley, incite boll rots regularly only in the drier western part of the U.S. Cotton Belt and other dry areas and are relatively xerophytic. *Aspergillus niger* boll rot is reported from dry areas in Egypt, Egyptian Sudan, Morocco, and West Pakistan, and several papers cite the presence of *Rhizopus* boll rot in Egypt (*35*). Like *Aspergillus flavus*, both of these fungi have dry spores that are adapted to dispersal in air currents and do not require free water for their dissemination (*13*).

All fungi, of course, require some moisture for their growth. Our emphasis on the semixerophytic nature of *Aspergillus flavus* should not be construed to indicate a belief that *Aspergillus flavus* boll rot would be expected to prevail under the driest known conditions of cotton culture and would not be favored by some additional

TABLE 3.—*Effect of prior exposure of cotton bolls to moist heat*[1] *on rate of browning and rapidity of sporulation of* Aspergillus niger

Age of bolls (days)	No. days to browning of burr		No. days to sporulation on burr[2]	
	Preheated	Not preheated	Preheated	Not preheated
50	2	2	2	4
45	4	6–8	5	9
40	4	6–8	5	8
35	5	11	8	14

[1] Treated at 56°C (133°F) for 30 min. Bolls subsequently incubated at 30°C (86°F).

[2] *A. niger* beginning to sporulate on heavy fungal growth along entire length of preheated stems after 3 days of incubation; very small amount of growth and sporulation on end of all peduncles of nonheated bolls after 4 days of incubation.

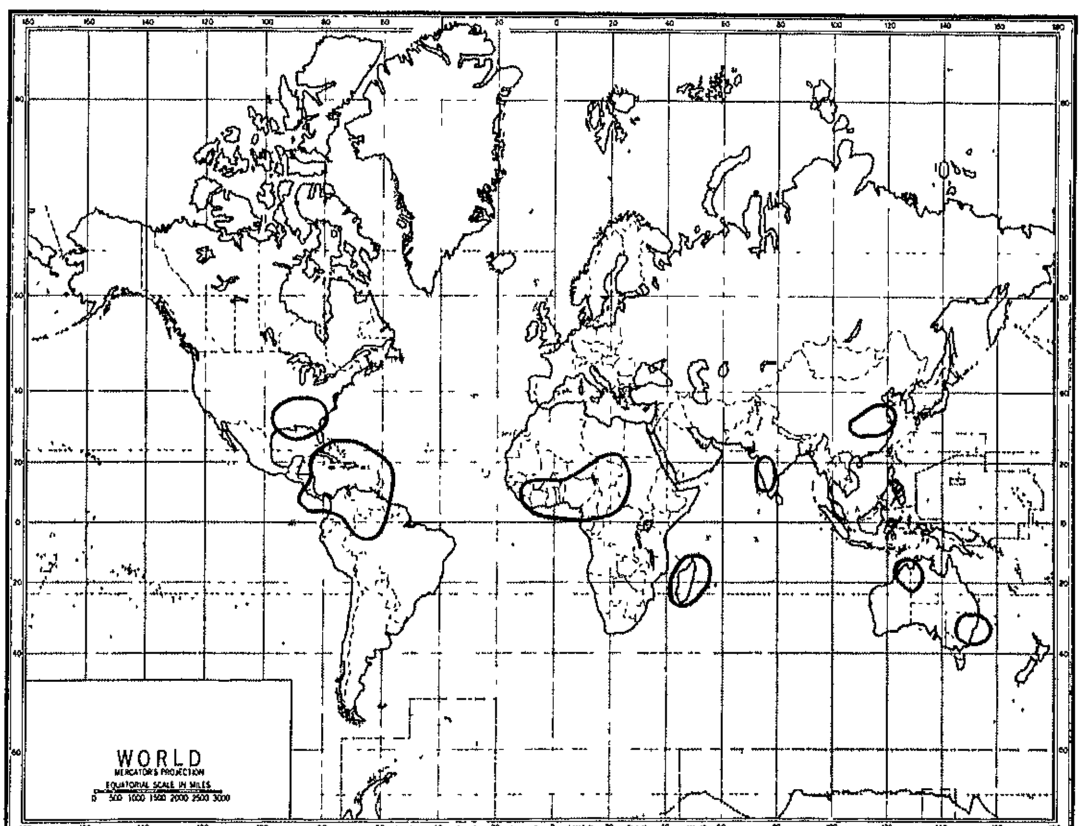

FIGURE 4.—World geographical distribution of a cotton boll rot caused by *Colletotrichum gossypii*. Note that occurrence is limited to areas of moderate to high rainfall.

moisture. Rather the concept is that the type of boll rot that predominates in a particular cotton-growing situation will be keyed to both the degree of water availability and the temperature. A reasonable comparison may perhaps be made with the situation in which differences in the fungal population of grain seeds in storage may be determined by the specific moisture level and the temperature (*28*).

Both temperature and moisture are known to have a direct effect on aflatoxin production independent of their effect on fungal growth (*10*). Under field conditions in cotton, however, the first prerequisite for aflatoxin contamination is that the fungus *Aspergillus flavus* shall be able to grow and infect the seeds.

Insect Damage and the Wound-Parasite Nature of *Aspergillus flavus*

Data obtained in our laboratory, reported in 1963, showed that in outdoor insect-cage experiments at Brownsville, Tex., the number of BGY-fluorescing spots in cotton fiber rose with increasing numbers of pink bollworm larvae introduced into the cages (*16*). In a more direct fashion, Ashworth et al. (*2*) demonstrated that pink bollworm damage to cotton bolls in the field often preceded and facilitated *Aspergillus flavus* infection. The fungus spores may find entry to the unopened boll through the exit hole of the pink bollworm in the boll wall. A general term for a fungus that infects a plant in this manner is "wound parasite."

Much published information suggests that *Aspergillus flavus* is a wound parasite and that it penetrates most intact plant cells with difficulty. Koehler (*15*) showed that it may cause a virescence or suppression of chlorophyll formation in corn, but that in order for infection and subsequent virescence to take place, the kernels had to be damaged. Many workers have found that infection of peanut pods is greatly facilitated by some sort of damage or breach in the integrity of the shell (*10*). In cotton fiber, *Aspergillus flavus* seemed quite unable to penetrate through the secondary wall to the fiber lumen, even though *Alternaria*, *Fusarium*, and *Colletotrichum* did so readily (*32*). The presence of only very weak cellulose-decomposing ability in *Aspergillus flavus* was shown by experiments in our laboratory (*17*). Numerous attempts to infect several kinds of plants with *Aspergillus flavus* were unsuccessful until the plant parts were scored with a scalpel before inoculation (*23*).

In cotton in the field, boll damage by the pink bollworm can facilitate infection not only by *Aspergillus flavus* (*2*), but also by other fungi as well, and the presence of the pink bollworm in the crop is not necessarily followed by infection with *Aspergillus flavus* rather than by infection with other fungi. As an example, the pink bollworm has been present for many years in the crop at El Paso, Tex., but the BGY fluorescence has been detected there only very rarely in our several surveys.

Competitive Ecological Balance

The adaptations of *Aspergillus flavus* to growth in hot, dry situations apparently provide a rational explanation for the prevalence of *Aspergillus flavus* boll rot in hot, dry, cotton-growing areas. These adaptations, however, do not offer an immediate, equally satisfying explanation for the virtual nonoccurrence of *Aspergillus flavus* boll rot in more humid and temperate cotton-growing regions. We must take into account the fact that *Aspergillus flavus* can grow not only at rather high temperatures and low moisture levels, but also at more moderate temperatures and higher moisture levels. Under the latter conditions in the field, however, we can reasonably assume that *Aspergillus flavus* is subject to the competitive action of many microorganisms that are unable to compete with it in hotter and drier areas. Thus, the ecological balance upon all substrates available for microbial growth is assumed to be relatively unfavorable to *Aspergillus flavus* in temperate-humid situations, and the component of *Aspergillus flavus* in the microbial population of the total environment to be relatively low. The spores of *Aspergillus flavus* die quite rapidly at about 75 percent relative humidity, just below the minimum humidity required for germination (*41*). This may also be an important factor leading to low levels of *Aspergillus flavus* in the environment in temperate-humid locations.

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NEW METHODS IN SEED COTTON HANDLING

By J. K. Jones[1]

There is nothing magical about the role of seed cotton handling and storage. What is significant about an inexpensive system of handling and storing seed cotton is how efficiently it makes other components function within the total field-to-mill system.

We must look not only at what has happened in the past and at the current situation, but we must also look at the near future and the possibilities of greatly increased costs of moving cotton from field to mill as a result of State and Federal regulations on highway and gin safety, litter and pollution controls, increased minimum wages and possible overtime payments, and a recent designation of cotton dust as a major health hazard. As a matter of plain fact, continuous improvement is necessary just to maintain current cost levels.

The main cost associated with the field-to-mill movement of cotton is capital investment, with the harvester or the gin being the most expensive item, depending on the annual volume per unit. Increasing annual volume is the most direct way to reduce this cost. This can be done in a combination of ways.

1. Plant part of your crop in a variety that matures 7 to 14 days earlier. Several such varieties are on the market now. Early maturing cotton can mean as much as a 20-percent increase in annual volume to harvesters and gins.

2. Increase field efficiency of harvesters. Under the present trailer system, a field efficiency of 60 to 65 percent is good, assuming proper supervision of adequate turnrow labor. But combines harvest beans or small grains with average field efficiency of 75 to 80 percent. Why shouldn't pickers and strippers operate at a field efficiency just as high?

3. Increase operating efficiency of the gin. USDA reported that the operation of gins in the Midsouth averaged only 49 percent of their expected capacity in 1971. Increasing operating efficiency to 70 or 80 percent of expected capacity is not hard to do under good management with some form of controlled flow of seed cotton.

4. Reduce peak demands in the storage, transportation, and marketing of cotton after ginning. Controlled flow of lint and seed from the gin can immediately reduce total costs in these areas by 10 to 15 percent. Further reductions are possible with one compression and accurate sampling at the gin, both of which in turn will allow more efficient marketing of the crop.

Seasonal variabilities due to crop maturity and weather patterns do not allow a uniform flow of cotton from the fields to the gin. Therefore, some economical system of accumulating and handling seed cotton between the harvester and the gin is essential. Such a system should allow the harvester to operate at full capacity when crop and weather conditions permit, increase picker field efficiency, and reduce turnrow labor. At the same time, the gin should operate at a constant rate during scheduled hours to obtain maximum efficiency from equipment and labor.

Let me review briefly the new technology in seed cotton handling and storage.

The currently popular, low-cost, mechanical ricking equipment developed at Texas Tech under the direction of Milton Smith eliminates the need for manual tramping, and it provides a very high capacity.

The idea of ricking cotton on the turnrow is not new. But the idea of ricking it *mechanically* is new. The design of the cotton rick compactor, with its flared sides, allows instant harvester dumping. The hydraulic compressor compacts the seed cotton into uniform dimensions and density that allow for efficient use of mechanical loaders. Capital investment is low, and use of the equipment blends in well with use of existing trailer systems. Our best estimate is that 500 of

[1] Cotton Incorporated, Raleigh, N.C. 27612.

these units are being used by growers in the Texas High Plains this year, 40 to 50 in the San Joaquin Valley of California, and 11 in the Mississippi Delta area.

In the High Plains area it is not necessary to cover the rick, if the rick is properly made. Some skill and know-how are necessary to insure that a rick is of uniform density to keep moisture from concentrating or penetrating the stack, and to prevent loss of seed cotton from high winds. An operator's manual has been prepared by Cotton Incorporated to help insure proper operation.

In high rainfall areas it is necessary to cover the rick with plastic and a holddown material, such as netting, or cover the rick completely with the plastic, anchoring the ends of the plastic with soil. Another alternative is to use the conventional 16-ounce cotton canvas tarpaulin.

The idea of forming seed cotton into freestanding modules on a pallet was first demonstrated by Xzin McNeal at the University of Arkansas in the mid-1960's. His work resulted in the development of the Arkansas cotton caddy, which employs labor to distribute and compress seed cotton to densities of 9 to 10 pounds per cubic foot.

In 1971 Cotton Incorporated, in cooperation with Texas A&M University and Lambert Wilkes, developed the fully mechanical seed cotton module former that compresses the cotton to 12–14 pounds per cubic foot. A prototype commercial unit was tested in the Rio Grande Valley of Texas in August 1972. During the 1972 season, 18 module builder units were used by growers in the Midsouth. In addition, on-farm research studies were conducted in Louisiana, Arkansas, Mississippi, Texas, and California to determine operating efficiencies and the quality of both lint and seed handled in modules.

The main advantages of the module operation are that the system has the same flexibility as a trailer system, can be phased into existing operations to replace trailers, or works in combination with trailers. In 1972, all but one grower used the module builder in conjunction with their trailers; therefore, thorough analysis of using only the module builder to handle cotton was not field tested, as should be done before making specific recommendations. But even used in conjunction with trailers, several module builders each handled 800 to 1,200 bales of cotton during peak periods.

Reed of Glen Allan, Miss., used the module builder without trailers during his first harvest. His experience was that turnrow labor was significantly reduced and that harvesting efficiency was increased by 15 to 20 percent. Growers using the module builder in conjunction with trailers experienced similar efficiencies.

From continuing research at Texas A&M, and from grower experiences this year, we are accumulating information that will improve the operating efficiency of the module builder for the coming year. Tests have shown that in high-yield cotton in which the new two-bale-plus harvester baskets are used, the time required to top out a module can be reduced by 50 percent with a faster cycling of the tamper, a wider tamper foot, and higher hydraulic pressure. These specifications will be published in the near future, along with modifications in the pallet designed to increase strength, utilize local materials, simplify construction, and reduce the time required to attach the pallet to the cable.

At the gin, no problems were experienced in using the conventional suck-pipe to remove seed cotton from the compressed module. In fact, some ginners reported that it was easier on the suckman and that he could feed the gin faster.

To automate the feeding of module cotton into the gin, a mechanical breakup-feed unit is being tested, and Cotton Incorporated plans to release this information in time for the 1973 season. The tests, under the direction of Lambert Wilkes at Texas A&M, are being conducted in the High Plains area at this time. The capacity of the experimental unit is 20 bales of machine picked cotton per hour.

When discussing the storing of seed cotton, the subject of preserving the quality of lint and seed always comes up. Numerous studies conducted by State agencies, USDA people, and growers over the last 20 years have clearly shown that when moisture in the seed cotton mass is below 12 percent, you can be sure that you will experience no deterioration in lint quality. Further, studies have shown that seed and trash are the most critical sources of moisture. If a high percentage of seed is hard, and if the trash is not green, little danger is involved—if the lint is dry enough to permit good harvesting.

Taking the first baskets picked in the morning and the last picked in the late evening direct to the gin should keep any risky cotton out of

module storage, especially if you do not have to consider excessive green leaf.

The best insurance against high-moisture seed cotton is good defoliation. You can take 8 percent seed cotton, add 10 percent by weight of green leaf, place it in dead storage, and you will increase seed moisture to 14–16 percent, which will deteriorate the seed and cause the lint to be spotted. On the other hand, growers have averaged half a grade increase in the quality of properly stored cotton.

Also keep in mind that high-volume harvesting only occurs in dry periods, when a majority of the seed cotton is safe for long-time storing.

In summary, Cotton Incorporated's efforts are being directed to increase capacity of harvesters so cotton can be harvested at the proper time under the best weather conditions. The harvester is the moneymaker within the system. It can increase your profits through higher machine efficiencies and greater volumes. The module builder allows both; in addition, it reduces labor now associated with turnrow and gin handling of seed cotton.

Some growers are beginning to measure efficiency in terms of man-hours per bale for harvesting, handling, ginning, and packaging. Some are now down to 2 man-hours per bale for all of these operations. It would be well for you to make this same type of analysis of your operation.

Mass seed cotton handling systems allow the gin season to be extended. However, our immediate concern is to fully utilize the gin during operating periods as they now exist. Substantial savings can be made with increased volumes. Increased volumes justify cost-saving and labor-saving equipment, such as the universal density press, automatic strapping and wrapping equipment, mechanical feeders of seed cotton, and mechanical sampler.

Competition in the fiber market will not permit cotton producers the luxury of ginning as fast as they can harvest.

MODERN GINNING TECHNIQUES
(ABSTRACT)

By Vernon P. Moore[1]

As far as can be determined, all of the ginning research carried on in the world has been by the ginning research laboratories of the USDA and the gin machinery manufacturers of the United States. It has been an excellent example of government-industry teamwork. The USDA has developed ideas and principles into prototypes, which in turn the machinery manufacturers have adapted to their manufacturing and production techniques. This teamwork, which has existed for more than 40 years, has resulted in systems to handle all types of cotton from commercial harvesters used at the present time.

The present recommended ginning systems for machine-picked cotton are based on direct developments of USDA. The feed control, cotton drier, grid bar cleaners, stick and green-leaf machines, high-capacity gin stands, and lint cleaners are all products of the USDA cotton ginning research program, which has made the mechanical harvesting of cotton economically feasible. Recommendations for the amount, sequence, and use of equipment have been worked out to preserve quality and use value.

The sequence of equipment necessary in a gin includes a feed control, drier, cleaner, stick and green-leaf machine, drier, cleaner, extractor-feeder, gin, and two lint cleaners. To prevent fiber damage, the system must be operated in accordance with recommendations which have been developed through extensive experimentation and fiber and spinning tests. To obtain grade for the producer, the seed cotton cleaning equipment must be sized in accordance with the rate of material to be fed through it. Two lint cleaners are needed to comb the fiber and remove "pin and pepper" trash. To preserve spinning quality, the driers should be operated to give a lint moisture content in the 7- to 8-percent range, which is a compromise between grade and use value. Lower moisture contents will increase grade and reduce use value, while higher moisture contents will increase use value and reduce grade.

Currently, the ginning research effort, aside from heavy involvement in quality preservation, includes research on noise and air pollution, trash collection and disposal, bale packaging, and aflatoxin in stored seed cotton and cottonseed. One very pressing problem is development of a means for removing large sticks from cotton harvested with new experimental machines, which harvest narrow-row and conventional plantings much faster than the familiar spindle pickers. A means for satisfactorily cleaning this material must be found if the full potentials of new lower cost production systems are to be fully realized.

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CHEMICAL STUDIES ON BYSSINOSIS, THE RESPIRATORY DISEASE OF COTTON MILL WORKERS

By P. A. Hedin, A. C. Thompson, and R. C. Gueldner[1]

Byssinosis is an occupational respiratory disease caused by inhalation of the dusts of fiber crops such as flax, soft hemp, and cotton. It is characterized by Monday symptoms of chest tightness, cough, and dyspnea, accompanied by a marked decrement in expiratory flow rate, and has been associated with an increased prevalence of chronic bronchitis and decreased ventilatory capacity. The prevalence of byssinosis in selected U.S. textile mills, as determined in five recent independent surveys involving more than 4,000 workers, has varied from 20 to 40 percent in the high-risk preparation areas, and as high as 25 percent in lower risk yarn processing and weaving areas (*5*).[2]

Byssinosis was first described in Italy in 1705 by Ramazini, who observed that flax workers developed characteristic respiratory symptoms. Subsequently, investigators such as Prausnitz (*6*) and Schilling (*7*) described similar respiratory symptoms in cotton mill workers. At present, the specific causative agents of this respiratory disease are unknown, although Taylor (personal communication) implicated plant pigments of the flavonoid type, and de Treville and Braun (personal communication) speculated that a bacterial enzyme present in cotton dust might be the causative agent. Also, methyl piperonylate (*2*) and polymers of quercetin and quercitrin (*1*) have been reported to evoke some of the byssinotic symptoms.

Similarly, the mechanisms of production of byssinotic symptoms, of decreased flow rates, and of subsequent chronic bronchitis are unknown. Bouhuys and Dutka (private communication) have suggested that a histamine release occurs in mast cells of the lung. Merchant et al. (*4*) described byssinosis as a dose-toxicity-response phenomenon. While clinical investigators have used human subjects to evaluate samples and fractions, efforts are in progress to develop small-animal bioassays. Kilburn (*3*) has exposed hamsters and guinea pigs to respirable dust and subsequently observed recruitment of polymorphonuclear leukocytes through the epithelium of the airways. Changes were also observed in the alveoli, with an increase in macrophages, which had phagocytized the dust particles.

Recently, Merchant et al. (*5*) reported that steaming cotton effects a dramatic decrease in the byssinotic response by susceptible workers. Almost no drop occurred in the forced expiratory ($FEV_{1.0}$) volume. Byssinotic symptoms occurred in 12 percent of these workers. While several approaches to a commercially feasible procedure for steaming cotton are being pursued, these investigators suggest this could best be accomplished at the cotton gin.

In this study, bale line cleaner waste was steam distilled, the resulting essential oil fractionated by column chromatography, and the fractions analyzed with an integrated gas chromatography-mass spectrometry system. The bale lint cleaner waste was selected for investigation because of its higher content in lower grade and stripper-picker cotton. These cottons have been shown to cause greater dust problems in the bale-opening rooms of the mills. Also, a

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[2] Italic numbers in parentheses refer to items in "Literature Cited" at the end of this paper.

greater incidence of byssinosis has been associated with lower grade and trash cotton. Water extracts of dried bracts have been shown to be particularly potent initiators of the response, and steam distillation of the bracts was selected as a potentially effective method to concentrate the causative agents.

From 153 mass spectral scans, structures for 67 components were proposed. The hydrocarbon fraction included 7 alkyl-substituted benzenes, 13 terpene hydrocarbons, and an alkyl hydrocarbon. The benzenes have been widely reported in plant materials, particularly after processing. All but two of the terpene hydrocarbons have been found in growing cotton. However, there were a number in growing cotton that were not present in the bale lint cleaner waste oil. These hydrocarbons account for 27.3 percent of the total oil.

There were several classes of compounds present which contained oxygen. Eighteen aromatic carbonyls were found and structures were proposed for 12. In total they account for less than 5 percent of the oil, but they are highly pungent and contribute significantly to the oil odor. Of these, only benzaldehyde and *p*-tolualdehyde were found in growing cotton. Another rather large class was the terpenoid carbonyl compounds; 14 were present and structures for 9 were proposed. Most of these are rather common in plants, and myrtenal was found in growing cotton. This class is also quite odorous and accounted for about 5 percent of the oil.

Also present were six aromatic alcohols and five terpene alcohols. Benzyl alcohol and 2-phenyl ethanol were found in growing cotton. Mostly because of β-bisabolol, the major oxygenated component in growing cotton, the alcohols comprise about 30 percent of the total oil.

Finally, 12 other oxygenated compounds, including 6 furans, 2 pyrans, 2 methyl esters, 1 lactone, and 1 epoxide, were found. They include bisabolene oxide and caryophyllene oxide, which were previously found in growing cotton. However, they also include several compounds which are typically produced by heating or roasting. The only two nitrogen-containing compounds were tetramethyl pyrazine, another typical roasting product, and indole.

Thus, the bale lint cleaner waste essential oil contains chiefly aromatic and terpenoid compounds, most of which are also present in growing cotton, but also others which are more likely to have been formed during storage or processing. Some of the components, particularly the aromatic ones, are stated by Merck Index to possess toxicity to some degree. While few, if any, are particularly unusual in essential oils, this may be a special case in which relatively large quantities are inhaled. Regrettably, neither the oil nor fractions therefrom have been clinically evaluated. When this work was initiated, there were expectations that clinical testing was to be carried out in the Respiratory Medicine Department at Duke Medical School. Unfortunately, the bioassay procedures never were developed to an adequate level to carry out volume screening. However, several groups are attempting to develop bioassays, and it is expected that evaluation of fractions will be possible shortly.

In other work, steamed and nonsteamed cottons have been steam distilled to yield the volatile (essential oil) fraction which has been subsequently analyzed by capillary column gas chromatography. It was expected that steamed cottons would be lower in the volatile content; however, with 50 samples, no appreciable qualitative or quantitative differences were observed.

Cotton has also been microwave treated, steam distilled, and the distillate analyzed by gas chromatography. Compared with an untreated sample, the total volatiles concentration actually is slightly higher. The microwave treatment appears to have had an effect, however, because several of the components changed gas chromatographic retention volumes. Isomerization or rearrangement may be implicated.

Since steaming of cotton in the intact bale has been shown to reduce byssinotic symptoms of cotton mill workers, the implication is that the steaming process purges causative volatiles from the bale. It is, of course, recognized that this removal of volatiles may be only an incidental process. However, the odor of the purged effluent and that in the bale opening rooms of the mills are essentially the same. Moreover, respiratory diseases experienced by workers in various industrial operations have usually been shown to be caused by volatile materials when particulate matter was not a factor. Since Kilburn (*3*) has shown that the byssinotic effect can be induced by preparations which were passed through a bacteriological filter, particulate matter does not seem to be the primary agent.

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TOWARD A NEW TEXTILE PROCESSING SYSTEM

By A. Baril[1]

In spite of the many improvements made to individual textile processing machines in recent years, machinery in the most modern cotton textile mill remains basically the same today as it was 200 years ago. To produce a woven or knitted fabric from a bale of cotton requires more than a dozen different steps. Between each of these steps, workers ranging from unskilled to skilled are required to handle the cotton. What is needed is an entirely new system that will not only eliminate many of these steps, but also most of the costly and time-consuming handling.

In 1966 the Cotton Textile Processing Laboratory started a research program which has been directed toward the manipulation of cotton fibers by aerodynamic, acoustical, magnetic, and electrostatic forces. To date, fundamental research has demonstrated that electrostatic forces have the most potential for adaptation to practical methods for handling and forming fibers into yarns.

Initially, the behavior of fibers in simple electric fields was studied so as to predict possible means of moving and manipulating fibers with more complex fields. One application of this research is a method of electrostatically fractionating fibers, i.e., separation of undesirable short cotton fibers from long cotton fibers. An experimental apparatus for fractionating cotton fibers is shown in figure 1.

This apparatus is based on the theory of nonuniform electric fields. A nonuniform field was obtained by specially shaping the electrodes to which the voltage was applied. In operation, cotton directly from the bale or in tuft form was fed between the electrodes in the region of minimum field intensity. The fibers were attracted and alined by the electric fields between each pair of cylindrical electrodes. The longer fibers migrated toward the region of high intensity more rapidly than the shorter fibers. Since shorter fibers were not as readily influenced by the electric field, they dropped onto the bottom electrodes and were removed from the field by the rotating cylinders. Exploratory investigations demonstrated that the alined fibers can be removed aerodynamically or mechanically and formed into a strand. It is anticipated that the fibers will eventually be removed by electrostatic forces.

Of far greater significance than the removal of short fibers from cotton is the fact that the experimental electrostatic device is a breakthrough on the road to a new system. This laboratory model demonstrates that a single machine could replace most of the textile processing

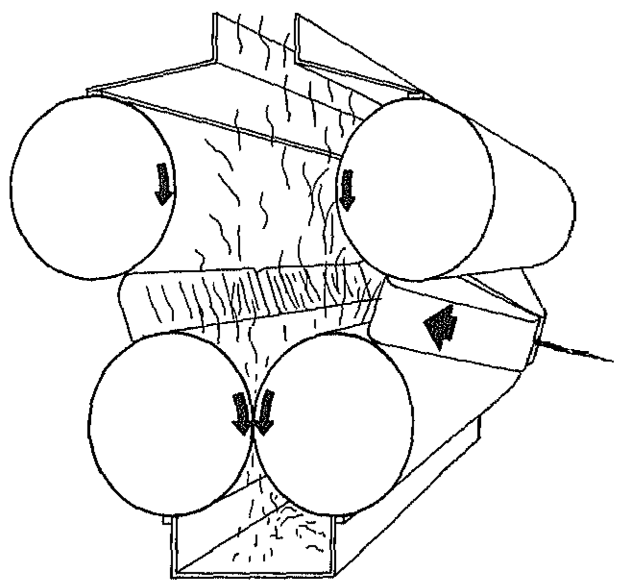

FIGURE 1.—Fiber fractionator.

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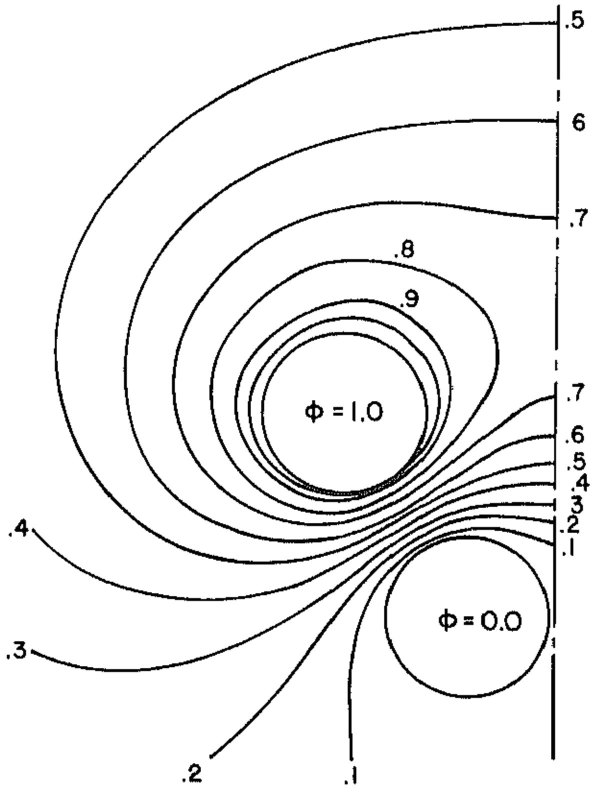

FIGURE 2.—Computer-mapped field of the fiber fractionator.

equipment from opening through drawing. The potential of this development is exciting.

To accelerate research on the new processing system, mathematical models were developed to simulate the movement of fibers in various electric field configurations. Computer analysis of these models enabled the study of fiber dynamics without the construction of prototype equipment. Field parameters with given boundary conditions were selected, and the computer solved and plotted the lines of equal voltages for each configuration studied.

By analysis of these plots, the action of fibers in such a defined field was determined. An excellent evaluation of the computer analysis of an electric field with its working counterpart was obtained by using high-speed motion pictures. The action of fibers in the device designed to fractionate cotton fibers by length was very close to that predicted by the computer.

A configuration of particular interest analyzed by the computer was that of a set of metal rings. Using this arrangement and maintaining a nonuniform, three-phase alternating electric field on the set of rings, charged fibers were made to move through the system. Such an arrangement offers a method of conveying cotton fibers in a quiescent air "electric duct." It is anticipated that by modifying the field configuration, condensation of the fiber into a strand can be achieved while the fibers are being transported through the electric duct.

Further research using the concept of moving cotton fibers by undulating electric fields has shown that a hopper could be developed so that individual fibers are held within a defined field area awaiting transportation through the electric duct. Maintaining a supply of individual fibers in an electric field accumulator has always been considered a very necessary factor of the proposed new textile processing system. This hopper could accomplish the job.

By additional computer analysis and design, the electric duct has been bent so that cotton fibers can now be made to travel around a corner, using electric fields as the motivating force.

During the study of cotton fiber behavior in electrostatic fields, there were several phenomena observed which could not be explained theoretically. This suggested the need for a more basic study of what is happening.

A study was conducted in which cotton fibers were considered as dielectric bodies, or insulators, which could acquire electrical charges on their surfaces. When such fibers are placed in an electric field, both positive and negative charges are formed on the surface of the fiber. As a result of the interaction between the charges on the fibers and the applied electric field, a force is applied to the fiber proportional to the field strength, making the fiber move parallel to the direction of the field and toward the region of maximum field strength.

Since the control of fiber movement in an electric field is directly related to the amount of charge on the fiber and the field configuration, it is essential to determine the amount of charge that can be deposited on individual fibers and fiber assemblies.

One method of measuring the value of the charge is to measure the angular displacement of a cotton sample while suspended in a defined field; the amount of rotation of the suspension is directly related to the charge deposited on the cotton sample.

These measurements established a basis of

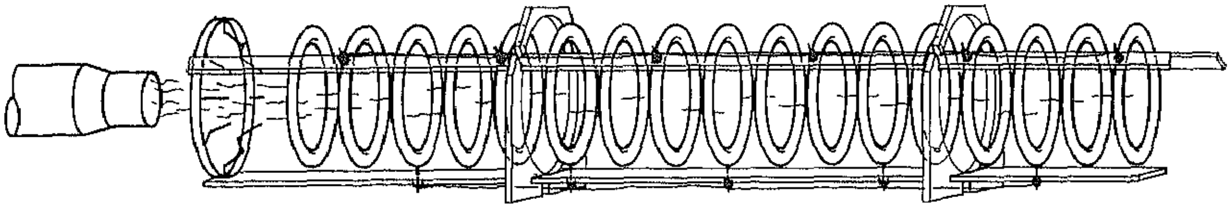

FIGURE 3.—Electric duct.

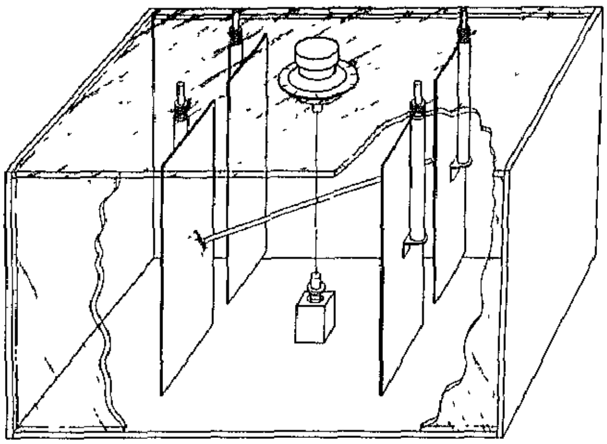

FIGURE 4.—Torsional apparatus for charge measurement. A nylon rod sample holder is suspended by a steel fiber with the end of the nylon rod in the center of the electrode configuration. Angular displacement of the suspension is measured by calibrated indicator.

comparison for current and future research on making cotton fibers more reactive to electrical forces. Such research is being directed toward modification of the fiber surface by addition of chemicals, by use of various gaseous atmospheres, and by control of atmospheric conditions.

This research has just begun; however, it has shown that the charge on cotton fibers is very dependent on moisture content of the atmosphere. At high relative humidities, fiber samples charge up rapidly, but once contact with an electrode is discontinued, the charge decays rapidly and the fibers respond sluggishly to an electric field.

The charge on an assembly of fibers is not only a function of humidity and temperature, but also a function of the geometry of the assembly. A loose aggregate of fibers will receive a larger charge than the same volume of tightly packed fibers.

We have discussed both the theoretical and experimental behavior and manipulation of fibers in electric fields; perhaps this is a good place to give an overview and progress report on how these factors relate to the development of the new textile processing system. As orginally envisioned, the system would start with tufts of cotton fibers and end with a yarn. A method of producing the tufts is available; what is needed is a means for separating these tufts into individual fibers and conveying them to a device, or so-called black box, where the fibers will be alined and formed into highly uniform textile yarns. All of these operations have to be performed with minimum labor and maximum production. Most of the steps of the process have been investigated on a fundamental level, and interesting results have encouraged continued effort to achieve a successful new textile processing system.

At present we have methods of separating the tufts into individual fibers; the mechanical effort involved at this stage needs to be reduced. Conveying of fibers by unconventional methods has been investigated, and considerable knowhow has been acquired. Concerning the last stage, the black box that turns the fibers into a yarn, patents have been obtained on a method for performing the task, and licenses have been granted to two companies to practice the patent.

Much has been accomplished toward achieving the goal of developing an entirely new and efficient nonmechanical system for processing cotton fibers into textiles. Already cotton fibers can be separated, cleaned, alined, conveyed, and spun by nonmechanical forces. It is not entirely clear at the moment how each step of the textile processing will be performed by the new system, but it is evident that many of the functions can be performed by electrostatic and aerodynamic forces.

THE RELATIVE IMPORTANCE OF COTTON FIBER PROPERTIES AND TEXTILE PROCESSING VARIABLES TO PRODUCT QUALITY AND PROCESSING PERFORMANCE

By Louis A. Fiori[1]

INTRODUCTION

Fiber properties are the nucleus upon which the ultimate utilization of cotton depends. Cotton fibers in yarns or fabrics are comparable to bricks and steel beams which, in engineering terms, are the main structural elements giving strength, rigidity, and esthetic properties to a building. Fibers geometrically resemble bricks and beams, since they have length, diameter, and cross-sectional characteristics. The physical properties of the fiber (strength, elasticity, rigidity, length, length uniformity, cross-sectional characteristics) and the orientation of the fibers (parallel, highly or loosely twisted, etc.) in yarns and fabrics not only influence the efficiency with which fibers are processed into fabric, but also determine the physical and esthetic properties and ultimately the performance of the final textile product.

A pound of cotton contains about 100 million fibers—50 billion fibers to the bale! To form a pound of yarn, 100 million fibers are reshuffled; they could extend 20 miles or more as, for example, in a man's dress shirt. Variables in processing these fibers must be controlled so that the 20 miles of yarn are relatively free of defects in order to meet consumer requirements of esthetics and wear.

However, before this can be accomplished, this mass of disorganized fibers from raw cotton having certain fiber properties must be transformed into an organized and parallelized fiber mass called yarn, which subsequently forms the structural elements of a fabric. The efficiency of this transformation is controlled by textile processing variables, such as twist, drafts, roll settings and weights, production rate, weights of fibrous masses, and doublings. Processing is an expensive operation, costing as much as or more than the raw cotton itself. Improper processing can damage even a cotton with the best physical properties and thus decrease the quality of the fabric.

Generally, cotton fiber properties are well known and are of direct interest to all segments of the cotton industry. In contrast, textile processing variables are virtually unknown to most of the cotton industry, except for the spinner who has the responsibility of preserving the properties bred into the cotton and realizing their fullest functional potential in yarns and fabrics by properly combining the processing variables as the cotton fibers journey from raw fiber to finished products.

This paper describes the relative contribution that fiber properties and textile processing variables make to yarn properties and processing efficiency.

COMPLEXITY OF PROBLEM

Maximum utilization of a cotton's fiber properties depends on knowledge of the complex interrelationships of production and ginning variables, fiber properties, textile processing

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variables, spinning efficiency, and yarn properties. These complex interrelationships are illustrated schematically in figure 1 and are all interdependent, so that changing one condition affects the other. For example, by selecting different processing conditions, two manufacturers may produce fabrics of the same quality but at different levels of processing efficiency, even though both used cottons with the same fiber properties. One manufacturer may use a more costly cotton without producing a better product than another only because he is not as knowledgeable as his competitor in selecting processing variables. The producer/ginner combination may mistreat the cotton and literally destroy a valuable fiber property such as length, in which case the manufacturer, regardless of what processing variable combinations he uses, can't produce a high-quality product at peak processing efficiency. The manufacturer may receive cotton with good fiber properties but destroy an important fiber property by improperly selecting processing variables, resulting in low-quality products and low processing efficiency. Therefore, to achieve maximum utilization of a cotton it is necessary to (1) preserve its original fiber properties from the growing field through the end product; (2) have knowledge of the contribution of each fiber property towards yarn properties and processing efficiency; and (3) select textile processing variables tailored to provide an economically and technologically balanced level of yarn properties and spinning efficiency.

FIBER PROPERTIES

Fiber Length and Length Distribution

Effect on properties.—Fiber length is usually expressed in terms of staple length, which is determined subjectively by a cotton classer, or in terms of span length, which is measured on a Digital Fibrograph. Length is considered the principal determinant of yarn and fabric strength; the longer the fiber, the stronger the yarns and fabrics. Long fibers tend to produce more imperfections, called neps, than short fibers; therefore the longer staple cottons are usually subjected to a combing operation which removes the neps and a large percentage of the short fibers and alines the fibers.

Length distribution (ratio of long fibers to short fibers) has a major effect on the appearance, strength, and uniformity of both yarn and fabric—a high content of short fibers degrades these properties. Cottons of low short-fiber content produce yarns and fabrics of more desirable properties than cottons of high short-fiber content, irrespective of average staple length.

Effect on processing efficiency.—Processing efficiency can be interpreted mainly in terms of the number of times a yarn breaks during the spinning and weaving operation. This action is commonly referred to as ends down—the larger the number, the lower the processing efficiency. Efficiency can also be interpreted in terms of the production rate during a particular operation —for example, carding, in which the fibers are first individualized and extraneous matter (trash, etc.) is removed.

Fiber length and length distribution are the major determinants of processing efficiency. Length, more than any other fiber property, establishes the finest yarn size (diameter) into which a cotton can be spun; the longer the fiber, the finer (smaller) the size of the yarn that can be spun.

Generally, long fibers can be spun at higher processing speeds than short fibers and require less twist to attain maximum yarn strength. Fewer ends down occur during the spinning operation (better spinning efficiency) with long fibers than with short ones. High short-fiber content significantly increases end breakage during spinning.

Fiber length, which is closely related to fineness, (long fibers are usually finer than short fibers) strongly influences the number of neps produced during carding. To reduce nep count at carding, lower production rates are necessary; therefore, long fibers are associated with low carding rates.

Fiber Fineness

Effect on properties.—Fiber fineness is measured by Micronaire or Fibronaire air porosity instruments and is reported in terms of Micronaire reading. Micronaire reading generally indicates the maturity of Upland cotton; for cottons of comparable staple lengths, a low reading indicates immaturity; a high reading, maturity.

Fineness is the fiber property that has the greatest influence on yarn and fabric appearance—the finer the fiber, the greater the detrimental effect. Fineness controls the number of

INTERRELATIONSHIPS OF PRODUCTION & GINNING VARIABLES, FIBER PROPERTIES, TEXTILE PROCESSING VARIABLES, YARN PROPERTIES, & SPINNING EFFICIENCY

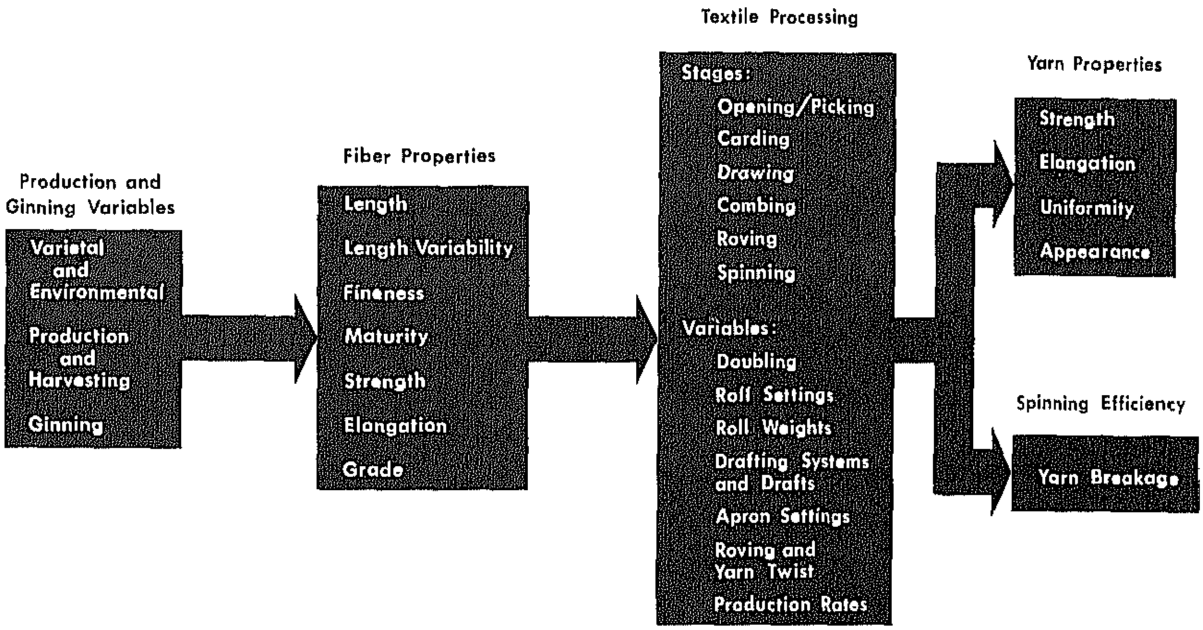

FIGURE 1

fibers per cross section of yarn; thus, it has a direct influence on yarn strength, but to a lesser degree than that of fiber length. In practice, the most desirable cotton within the same staple length is of average fineness. A fine cotton or a coarse cotton reduces quality, the former by increasing imperfections and degrading appearance, and the latter by reducing yarn strength.

Effect on processing efficiency.—Fineness, like length, controls the finest yarn size that can be produced. However, its influence on yarn size is less than that of fiber length. Also, like length, but to a much greater extent, fineness increases nep count and therefore causes carding speed to be reduced.

Yarn made from fine-fibered cotton can be spun with fewer end breakages than coarse-fibered cotton, but only as long as the fiber is reasonably mature. Very immature fiber could greatly increase end breakage.

Textile mills purchase cottons that are either too fine or too coarse at discounts. Cottons of average fineness or maturity sometimes command premiums, particularly if the fibers are high in strength and uniform in length distribution.

Fiber Strength

Effect on properties.—Fiber strength, which is usually expressed in pounds per square inch, ranges from about 70,000 to 110,000 pounds per square inch, measured by breaking a small bundle of fibers clamped between two jaws on the Stelometer or Pressley instruments. Stronger fibers produce stronger yarns and fabrics; however, the effects of differences in fiber strength tend to become smaller in successive processing from yarn to finished fabrics.

Effect on processing efficiency.—Fiber

strength has little effect on the efficiency of processing at any of the textile operations. Textile mills often pay a premium price for cottons with high fiber strength, since this property can be substituted for length when strength is a requisite in the end product.

Grade

Effect on properties.—While technically not a physical property of cotton, grade is very important to textile processing and product quality. Grade, which is determined subjectively by a cotton classer, is an index that collectively describes trash content, roughness of appearance (gin preparation), and color. Color can be measured quantitatively with an instrument called the colorimeter, and the color of cotton reported in terms of grayness and yellowness. Trash can be measured quantitatively with the Shirley analyzer and the SRRL nonlint tester instruments.

Trash content affects the appearance of yarns and fabrics—the lower the grade, the lower the quality. Trash is not known to affect any other properties of yarns or fabrics.

Color can affect dyeing, depending on the source of the color or "spot" in the cotton. Mixing cottons of different colors can affect the appearance of dyed materials, causing filling bars, streaks, bands, etc. Most off-color cotton can be satisfactorily bleached during chemical finishing.

Effect on processing efficiency—The grade of the cotton has an effect on overall processing efficiency. Cottons that are low grade because of weather damage or excess trash content increase manufacturing waste and decrease processing efficiency. Mills pay premiums for white, low-trash-content cotton.

Elongation

Effect on properties.—Fiber bundle elongation, which is the amount a fiber will extend before breaking, is expressed in percent and is commonly measured by the Stelometer at the same time that fiber strength is measured.

High fiber elongation produces yarns of high elongation, but its effect on other yarn properties and end breakage is small. Its effect on fabric elongation is complex. Higher elongation fibers convert into higher elongation gray fabrics, but as the fabrics undergo finishing treatments, the interchange of warp and filling elongation and the interaction of the geometry of the fabric itself minimize the influence of fiber elongation on fabric elongation. Fiber elongation is considered the least important of the cotton fiber properties. Cottons differing greatly in elongation values are not obtainable in large quantities, so the average of the crop is within very narrow limits.

Effect on processing efficiency.—Fiber elongation has no major effect on processing efficiency before spinning, but does slightly affect end breakage during spinning—the greater the elongation, the lower the rate of end breakage.

Mills do not pay premiums for high-elongation cottons. Even when this measurement is made, elongation is not ordinarily considered in mill operations.

Processing Variables

Carding variables.—The multifunctions of carding involve fiber-to-fiber separation, removal of trash, reduction of neps, and control of fiber orientation (hooks and alinement).

Carding variables, such as cylinder speed, sliver weight, doffer-to-cylinder speed ratio, and production rates, can be selected to attain a specific level of performance. For example, high production rates reduce waste, improve fiber alinement, and reduce fiber hooks, with resultant improvement in yarn uniformity and spinning efficiency. However, high production rates increase neps. Carding variables can be adjusted to minimize nep formation. Generally, with a cotton of average nepping potential, high carding rate, high doffer speed, and lightweight sliver improve fiber orientation with only a moderate increase in neps.

Drawing variables.—The function of the drawing process is to blend and aline the fibers, reduce hooks, and reduce long-term variation. The main processing variables are roll settings, total drafts, draft distribution, draft direction, and, to a lesser extent, web tension. Modern drawing frames can process cottons with a wide range of fiber properties without major adjustment in processing variables.

Long-term variation (1 yard and longer) introduced into the card sliver by the carding operation is reduced considerably by blending 6

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to 10 slivers in the drawing process; however, as a result of drafting, short-term variations (shorter than 1 yard) are not reduced and in the first and second drawing processes for cotton, are actually increased.

Large total draft improves parallelization, but in most cases decreases sliver uniformity. Total draft is probably the most important drawing frame variable for processing all-cotton material. Total drafts at second drawing should be higher than at first drawing. This results in improved fiber orientation and gradual reduction of card sliver weight prior to the roving stage.

Drafting direction was recently recognized as an important drawing frame variable. The direction in which the majority hooks are processed in drawing influences the rate of fiber hook reduction and fiber parallelization—the fewer the hooks and the more parallel the fibers, the better the processing performance.

Combing variables.—In this process, a large percentage of trash, neps, and short fibers are removed from the cotton. This waste is called noils. The resulting combed sliver is relatively free from imperfections and short fibers. Main variables are percentage noil extraction, roll settings, and draft distribution.

For minimum noil extraction without sacrificing sliver quality, the cotton must have a relatively uniform length distribution, and the lap must be fed into the comb with the majority hooks leading.

To eliminate drafting wave effects in the combed sliver, draft should be very low in the back zone and high in the front zone.

Roving variables.—In this process, the fibers are made more parallel and are drafted into a smaller size, slightly twisted strand called roving. The objective is to produce a uniform roving, free from drafting waves and short-term imperfections called slubs, with the fibers parallel and relatively free of hooks.

Important processing variables are roll settings, break and total drafts, sliver weight, and twist. Roll settings and break drafts can be combined to produce uniform roving for any given set of fiber properties. Total draft and sliver weight collectively are the main determinants of fiber parallelization and hook reduction. The higher draft required to process a heavy sliver into the same size roving as from a light sliver could improve fiber parallelization, but would decrease roving uniformity.

Fiber length and length distribution are the properties to be considered in selecting roll settings and break drafts. The general rule is to space the rolls as close as possible without causing fiber breakage, undrafted sections, and slubs, and then adjust the break draft to obtain uniform roving, free of drafting waves. Generally, with 100-percent cotton, break drafts have a greater effect on roving uniformity than roll settings.

Spinning variables.—The final yarn structure is formed and permanent twist is inserted during spinning. Modern spinning machines operate at high drafts and spindle speeds, so that processing variables at this stage—twist, total draft, draft distribution, apron settings, spindle speed—are more critical and contribute more to yarn properties and spinning efficiency than do processing variables at the prespinning stages.

Twist affects yarn strength and elongation more than any other processing variable, but affects uniformity only slightly. It has a significant effect on spinning efficiency (yarn breakage in spinning), particularly at the low twists normally used for filling and knitting yarns.

Spindle speed has an appreciable effect on spinning efficiency, a small effect on yarn elongation, and no effect on the other yarn properties.

Break drafts and apron space settings are critical variables, particularly with respect to fiber length and length distribution, and they affect spinning efficiency more than yarn properties. As break draft is reduced, apron setting is usually widened.

High total draft can be used for coarse or fine yarns without sacrificing yarn strength. This processing variable has a greater influence on spinning efficiency than on yarn properties. However, total drafts that are too high introduce drafting waves and decrease uniformity.

Yarn tension affects yarn elongation, but no other yarn property. If tension is too high, end breakage becomes excessive.

SUMMARY

Fiber properties and textile processing variables affect the physical properties of yarns differently. Processing variables mainly influence uniformity and, to a lesser extent, appearance,

as characterized by the number of thick and thin places. Fiber properties mainly influence strength and appearance as characterized by imperfections called neps. In contrast, processing variables and fiber length and length distribution have a great effect on spinning efficiency.

Fiber properties, mechanical processing variables, yarn and fabric structural elements, and weave must be considered collectively in establishing manufacturing costs and fabric marketability.

Figure 1 and tables 1–5 summarize the effects that fiber properties and processing variables exert on sliver and roving quality, spinning efficiency, and yarn properties.

TABLE 1.—*Effect of fiber properties on yarn properties and spinning efficiency*

Fiber properties	Yarn properties: Strength	Uniformity	Appearance	Elongation	End breakage
Length	Large	Small	Large	Negligible	Large.
Length variability	do.	Large	Small	do	Do.
Fineness[1]	Small	Small	Large	do	Small.
Maturity[2]	do	do	do	do	Do.
Strength	Large	do	Negligible	do	Do.
Grade[3]	Negligible	Negligible	Small	do	Do.
Elongation	do	do	Negligible	Large	Do.

[1] Intrinsic fineness.
[2] Thin-walled fibers within the same variety and staple length group.
[3] Not a true fiber property, but considered as such.

TABLE 2.—*Effect of carding variables on card sliver quality*

Processing variable	Unformity	Hooks	Parallelization	Waste	Neps
Card production	Small	Large	Large	Large	Small.
Sliver weight	do	do	do	Small	Do.
Flat speed	Negligible	Negligible	Negligible	Large	Negligible.
Cylinder speed	Small	Small	Small	Small	Small.

TABLE 3.—*Effect of drawing frame variables on drawing sliver quality*

Processing variable	Uniformity	Hooks	Parallelization
Roll settings	Large.	Negligible	Negligible.
Draft distribution	Small	do	Do.
Total draft	Large	Large	Large.
Doublings	Small	Negligible	Negligible.
Drafting direction[1]	do	Large	Small.
Sliver weight	do	Small	Do.

[1] Direction of hooks (trailing or leading in largest numbers) in sliver being fed to the drawing operation.

TABLE 4.—*Effect of roving variables on roving quality*

Processing variable	Uniformity	Slubs	Hooks	Parallelization
Roll settings	Large	Large	Negligible	Small.
Break draft	do	do	do	Do.
Total draft	do	Small	Large	Large.
Twist	Negligible	Negligible	Negligible	Negligible.
Sliver weight	Large	Small	Small	Small.
Drafting direction[1]	Small	Negligible	Large	Do.

[1] Direction of hooks (trailing or leading in largest numbers) in sliver fed to the roving operation.

TABLE 5.—*Effect of major spinning variables on yarn properties and spinning efficiency*

Processing variable	Yarn properties				End breakage
	Strength	Elongation	Uniformity	Appearance	
Twist	Large	Large	Negligible	Negligible	Large.
Break draft	Negligible	Negligible	Small	do	Small.
Total draft	do	do	do	do	Large.
Spindle speed	do	Small	Negligible	do	Do.
Apron settings	do	Negligible	do	do	Do.
Yarn number	Large	Small	Small	Small	Do.
Roll settings	Small	Negligible	do	Negligible	Do.
Draft direction[1]	do	do	do	do	Do.
Yarn tension	Negligible	Small	Negligible	do	Do.

[1] Direction of hooks (trailing or leading in largest numbers) in roving being fed to the spinning operation.

COTTONSEED PROTEIN PRODUCTS

By Wilda H. Martinez[1]

The cottonseed is many things to many people. To the farmer, it is part of his crop—2 pounds of seed for every pound of fiber. Though the economic value bears no relationship to the weight yield, the value of the seed is a significant part of the farmer's return per acre. To the oilseed processor, the cottonseed is the raw material from which he derives both his products and profit. To the food industry, it is a source of edible oil and a potential source of edible protein. Through the use of cottonseed protein, the food industry could extend and complement present animal protein supplies with the relatively low-cost vegetable protein, and provide the consumer with nutritious products in a convenient form. The cottonseed, therefore, can be of value to the farmer, to industry, and to the consumer.

The research that I would like to discuss is directed toward the latter aspect, that is, the food use of cottonseed protein. In addition to the multifaceted economic aspects, the cottonseed also encompasses many different types of research problems. Therefore, in my discussion I will also attempt to point out how other areas of research can aid and influence the rate at which the cottonseed proteins enter the edible market.

Figure 1 contains longitudinal sections of glanded and glandless cottonseed. This is our raw material. The first problem we encounter is the hull. The short fibers, or linters, attached to the hull make cottonseed unique among the oilseeds and require special delintering equipment. If the linters were essentially eliminated through breeding, then (1) the costly delintering operation could be terminated, (2) a potentially serious air pollution problem would be solved, (3) the cottonseed processor would have a more sanitary operation (sanitation is necessary in feed as well as food), and (4) the cottonseed would lose a major aspect of its processing uniqueness. The processor could then shift from the exclusive operation of cottonseed processing to the more economically advantageous and inclusive operation of oilseed processing on an annual basis.

As we move into the seed kernel, the next major problem we encounter is the pigment gland. This extracellular particle contains the physiologically deleterious compound, gossypol. In order to overcome the problems of gossypol, the oilseed processor must again utilize special equipment or special conditions to inactivate it. In many instances, he uses a prepress solvent operation rather than a direct solvent operaton to process his seed. Even with a solvent operation, the processor must introduce additional heat and moisture at either of two steps, conditioning or desolventization, to provide a physiologically acceptable product. Such a product is highly acceptable to certain aspects of the feed industry and totally unacceptable to most of the food industry. It is too high in color and too low in nutritive and many of the so-called functional characteristics desired by the food industry.

Development of glandless varieties through breeding is one way in which the gossypol problem can be eliminated (fig. 1). Glandless varieties are available which very nearly match glanded varieties in yield. With proper processing, defatted glandless cottonseed meal could freely enter any phase of the mixed feed industry, ruminant or nonruminant, including pet food. With proper sanitation, desolventization, and reduction in particle size, defatted glandless cottonseed flour could also very readily and freely enter the food market.

Engineering has provided another solution to the gossypol problem. Figure 3 is a scanning electron micrograph of the cotyledons of glanded cottonseed. The large, bulbous shape is a pigment

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FIGURE 1.—Longitudinal sections of glanded and glandless cottonseed.

gland. The small shapes are individual cells. With this difference in size, the problem becomes one of maintenance of pigment gland integrity.

The Engineering and Development Laboratory of the Southern Regional Research Center has devised a procedure called the liquid cyclone process[2] (fig. 4) which separates the intact glands, separates the oil, and provides, with the proper attention to sanitation, an edible protein product which more nearly approximates a concentrate, i.e., a product with 70 percent protein. A single cyclone as used in this process can process enough 20 to 22 percent solids slurry (milled meats, hexane-oil miscella) to produce 12 tons of cottonseed flour per day. The overs fraction yields the edible-grade flour. The unders fraction, which is high in pigment glands and gossypol pigmentation, is currently being evaluated as a pesticide.

A commercial plant based on this process is presently under construction at the Plains Cooperative Oil Mill at Lubbock, Tex., with startup scheduled for late spring or early summer. The total flour production will be marketed by the Grain Processing Corporation of Muscatine, Iowa. Preliminary evaluation of the liquid cyclone process (LCP) flour by this company and others has indicated that the product should find ready acceptance in bakery goods, meat patties,

[2] Gardner, H. K., Jr., Hron, R. J., Sr., and Ridlehuber, J. M. 1975. The production of edible flour from cottonseed. Proc. 22d Oilseed Processing Clinic. Agric. Res. Serv. [Rep.] ARS-S-48, pp. 27–33.

candies, and desserts.[3] The underflow, in large measure, will be incorporated with the normal meal operation of the oil mill and used as ruminant feed.

With glandless cottonseed the liquid cyclone process could produce two edible-grade products, the overs and unders, which would have different characteristics and therefore different uses. In fig. 5 we see the cottonseed at the subcellular level. Everything is neatly compartmentalized—protein, oil, and phosphorus. These particulates are embedded and surrounded by the normal cellular constituents. The cellular tissue, once defatted, offers the potential of providing a number of protein products which are differentiated on the basis of protein content.

[3] Olson, R. L. 1973. Evaluation of LCP cottonseed flour. Oil Mill Gaz. 77 (9): 7–8.

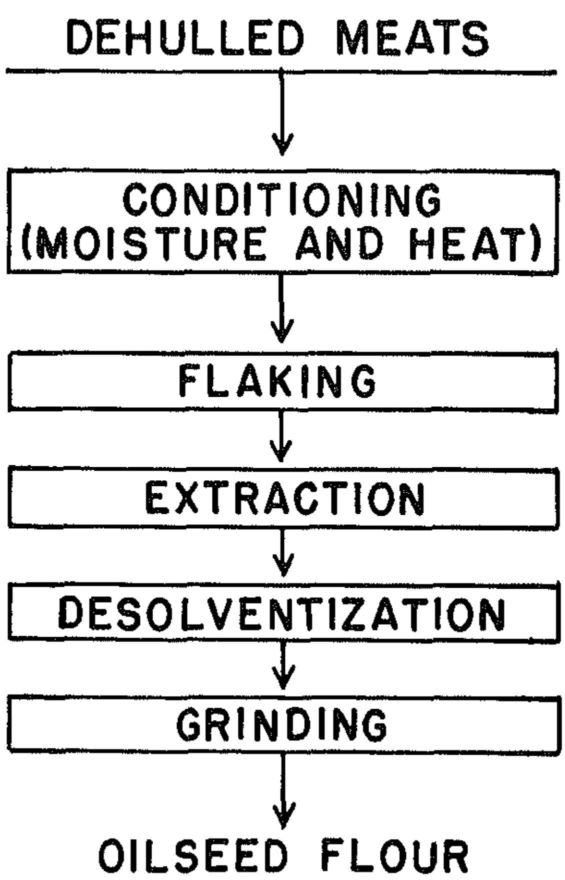

FIGURE 2.—Unit operations in oilseed processing.

These concentrates will differ in protein and nonprotein composition and characteristics from those produced by particle classification.

The third class of protein products is called isolates, containing about 90 percent protein. In contrast to methods used to produce concentrates, in isolate production the protein rather than the nonprotein constituents are extracted.

We know a number of pertinent facts about the undenatured proteins of the cottonseed. About one-fourth of the proteins are water extractable. These proteins are the cytoplasmic or functional proteins of the cell, i.e., they are the nonstorage proteins and are greatly affected by the heat and moisture used during processing. They are low in molecular weight and have a sedimentation coefficient of 2*s* in the ultracentrifuge.[4]

Two-thirds of the proteins of the cottonseed are not water extractable and can only be extracted by salt or alkali. These proteins are high in molecular weight and consist predominantly of the storage proteins of the cell.[5] Once they are extracted, these two groups of proteins, storage and nonstorage, differ also in solubility profiles (fig. 6).

Normally, protein isolates are prepared by what we term the classical procedure, that is, maximum extraction of the proteins at an alkaline pH followed by maximum precipitation at the pH of minimum solubility. The classical isolate, therefore, contains both groups of proteins, storage (SP) and nonstorage (NSP). However, these two groups of proteins can be isolated separately either on the basis of extractability (fig. 7) or the pH of minimum solubility (fig. 8). These procedures result in products which differ markedly in composition and amino acid content (table 1).

The differences in amino acid composition between the two groups of proteins offer the interesting possibility of genetic manipulation of the amino acid content of cottonseed. By changing the relative proportion of storage to nonstorage proteins, it should be possible to significantly increase the lysine content of defatted cottonseed flour. Such a change could be very impor-

[4] Martinez, W. H., Berardi, L. C., and Goldblatt, L. A. 1970. Potential of cottonseed: Products, composition and use. Proc. Third Int. Congr. Food Sci. Technol. (SOS/70) 248–261.

[5] Ibid.

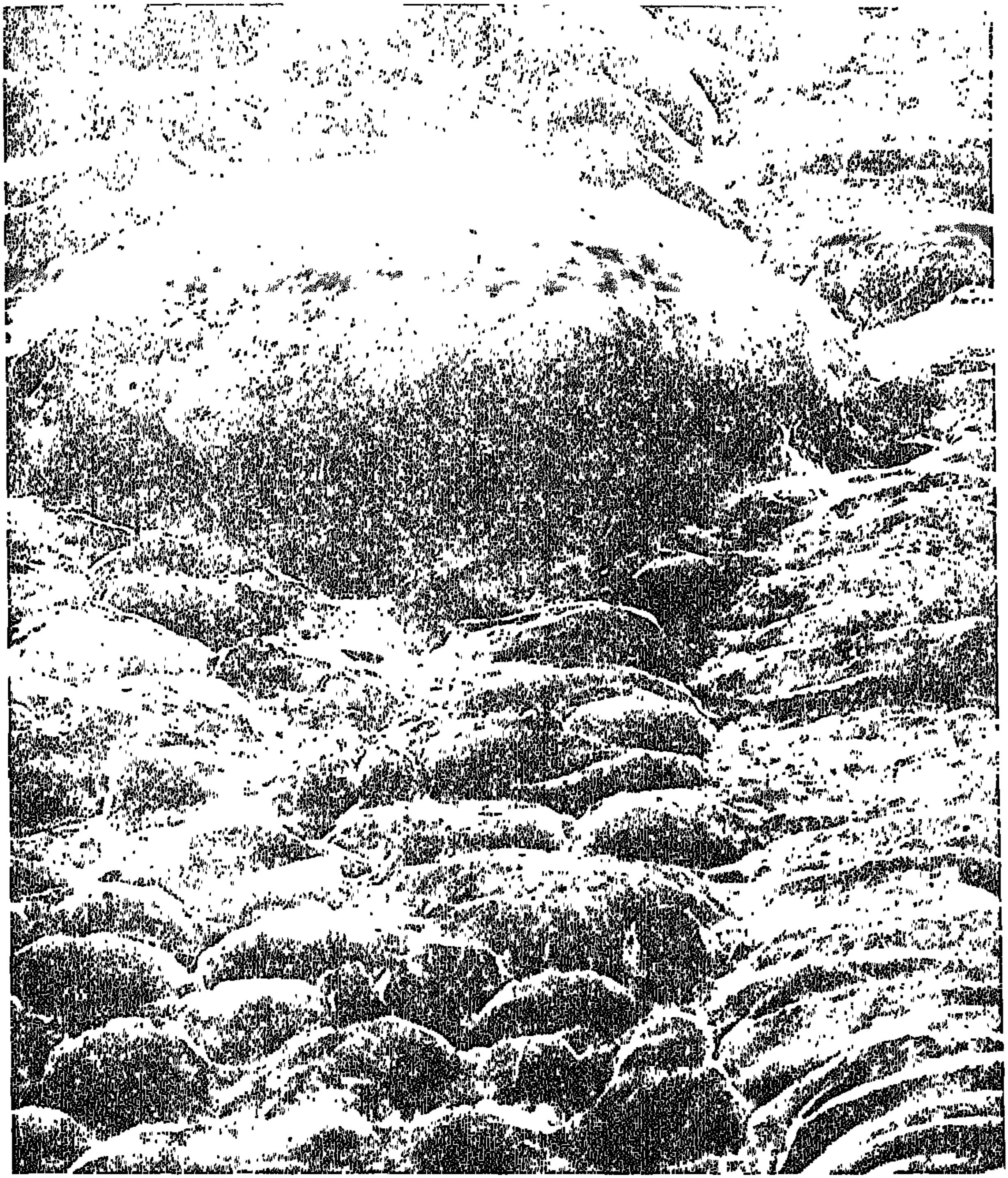

FIGURE 3.—Scanning electromicrograph of cross section of hydrated, glanded cottonseed. Large, bulbous shape is a pigment gland. (Courtesy of W. R. Goynes, Jr.)

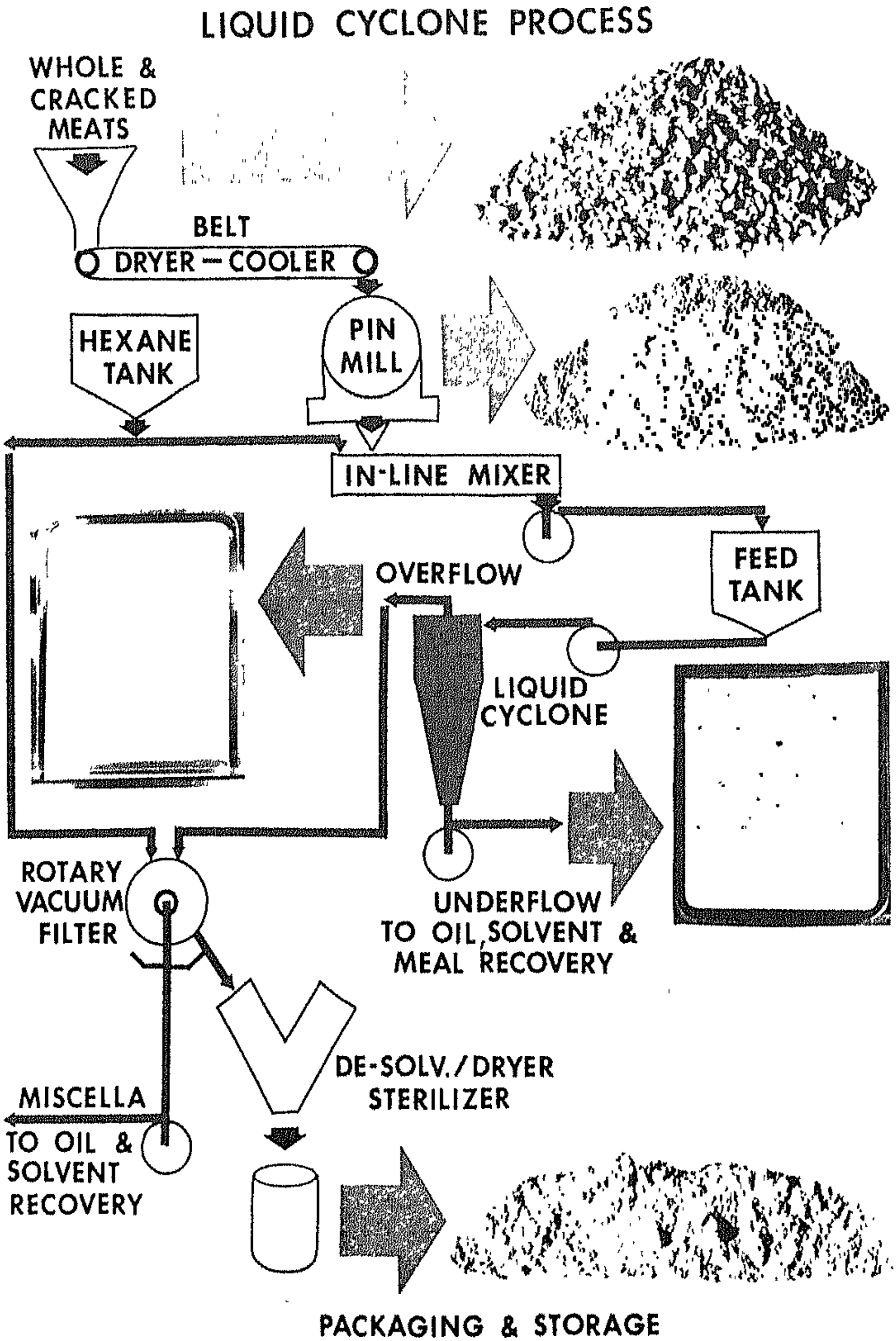

FIGURE 4.—Liquid cyclone process.

FIGURE 5.—Spongy mesophyll cells from cottonseed cotyledon. (Courtesy of L. Y. Yatsu.)

TABLE 1.—*Proximate and amino acid composition of glandless cottonseed flour and isolates*

Constituent	Flour	Isolates: Classical method, NSP and SP	Isolates: Selective extraction NSP[1]	Isolates: Selective extraction SP
Composition (%):[2]				
Nitrogen	10.73	15.58	13.08	17.24
Crude fiber	2.2	.5	.5	.2
Lipid	.9	1.1	3.0	.2
Ash	7.8	3.4	14.1	1.0
Phosphorus	2.19	.69	3.13	.26
Total sugar	7.3	.5	.5	.0
Amino acid (g/16 g N):				
Lysine	4.4	3.4	6.0	3.0
Histidine	2.9	2.9	2.6	3.0
Arginine	12.4	10.0	10.4	11.3
Aspartic	9.1	9.0	6.7	8.4
Theronine	3.0	2.9	2.9	2.7
Serine	4.1	4.0	3.4	4.5
Glutamic	20.4	16.4	21.8	18.9
Proline	3.6	3.4	3.1	3.1
Glycine	4.1	3.5	3.2	3.7
Alanine	3.7	3.6	3.2	3.5
Valine	4.6	4.7	3.3	4.4
1/2 cystine	....	.....	2.6	.3
Methionine	1.3	1.4	1.7	1.0
Isoleucine	3.4	3.4	2.6	3.1
Leucine	5.8	5.7	5.1	5.8
Tyrosine	3.1	2.8	3.3	2.6
Phenylalanine	5.5	5.7	3.7	6.3

[1] Neutralized.
[2] Dry-weight basis.

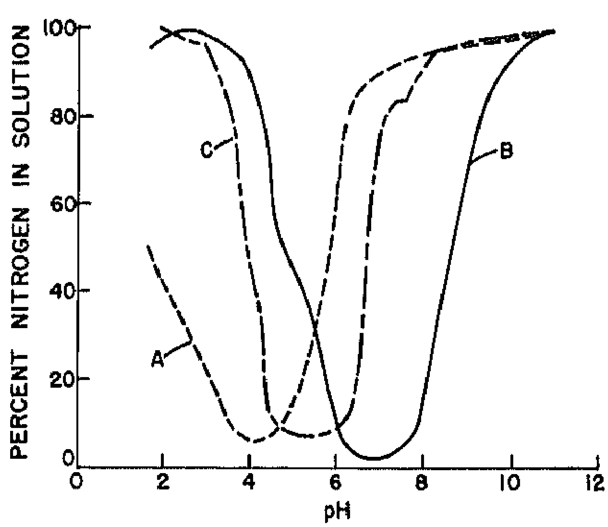

FIGURE 6.—Nitrogen solubility curves of 1-percent solutions of isolates from the classical and selective extraction procedures. Curve A, nonstorage protein (NSP) isolate; curve B, storage protein (SP) isolate; curve C, classical isolate.

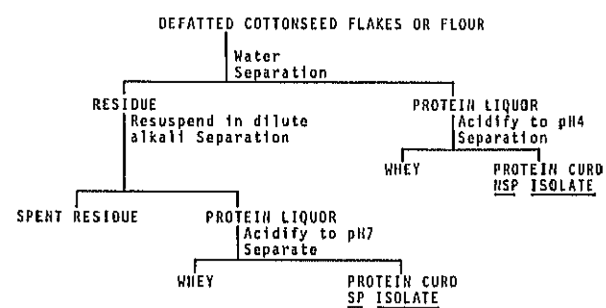

FIGURE 7.—Selective extraction procedure for the preparation of cottonseed isolates.

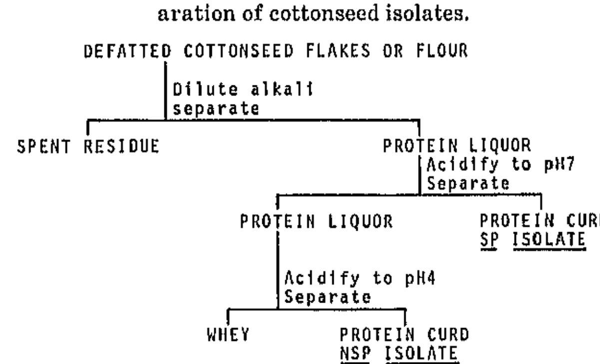

FIGURE 8.—Selective precipitation procedure for the preparation of cottonseed isolates.

tant to the nutritive quality of cottonseed protein products for both feed and food use.

One might well ask, "Why develop so many different cottonseed products?" The answer is based in economics. The food fabricator will utilize the product which meets his needs at the cheapest cost. Different products have different composition, different types of proteins, and different amino acid composition. These differences mean different functional characteristics and consequently different end uses. For example, the nonstorage protein isolate is poorly soluble, but has an excellent amino acid composition and high nutritive value. Its best use, therefore, would be as an inert nutritional supplement.

The storage proteins, in turn, have several interesting functional characteristics. They have excellent foam capacity and stability at an acid pH and could be used to replace milk solids. They are acid soluble and could be used to fortify citric acid type beverages. Under the proper conditions of concentration, pH, and temperature, they can be converted to different textures ranging from gels to a chewy, meatlike mass.

If it should sound as if we have solved all problems, let me quickly state that some of the most difficult research is yet to be done. For certain applications, there is a problem with even the small amount of color which still remains in the LCP flour. A portion of this color is also associated with the isolates. In addition, there is a need to increase the yield of edible flour from the liquid cyclone process and to gain a better understanding of the relationship between protein composition and conformation, and the resultant functional characteristics. With such knowledge, it should be possible to tailor the functional characteristics of the protein product to the end-use requirements.

The thought concerning cottonseed that I would most like to leave with you is this: Cottonseed is not merely the germ plasm for the growth of the cotton fiber. It is the source of a progression of protein products for food and feed, and, also, the source of a very real set of research problems.

PROGRAM AND PROGRESS ON COTTON/SYNTHETIC FIBER BLEND RESEARCH

By E. C. Kingsbery[1]

In early 1971 a research program was initiated on cotton/synthetic fiber blends. The purpose of this reasearch was to optimize the cotton component of cotton/synthetic blended textile products; to study the effects of certain processing variables on cotton/synthetic blends at different blend levels; and to develop techniques for more efficiently blending cotton and synthetic fibers to produce more uniform products from the standpoint of blend homogeneity.

In order to make the transition from processing 100-percent cotton fibers to cotton/synthetic blends, existing equipment had to be modified in certain instances, and blending equipment had to be purchased and installed for opening room blending. Consultations with synthetic fiber producers and textile manufacturers were also necessary.

Because polyester fiber is the predominant synthetic fiber used to blend with cotton, a 1½-inch staple and 1.5- and 2.25-denier high-tenacity polyester were selected for blending investigations with cotton.

Most of the textile industry engaged in processing cotton/polyester blends combine the cotton and polyester fibers in sliver form (combed and carded) at the drawframe process. To obtain good fiber homogeneity, high-quality slivers, rovings, and yarns, and optimize each fiber's contribution, it is necessary for the processing variables during these processes to be properly combined. To achieve this objective, a study was initiated to evaluate the processing variables at drawing, roving, and spinning. A medium-staple cotton of average fiber properties and the 1.5-denier polyester fiber were blended in sliver form at the first (or breaker) drawframe. Various blend levels, the cotton component being 80, 60, 50, and 30 percent, were processed through the drawing and roving processes with different roll settings and draft combinations. Guides are being developed for roll settings and drafts which will produce the best quality sliver and roving. The best quality rovings from each blend level will be processed into yarns, using a series of spinning processing variables. As with roving, guides will be developed for roll settings, draft distributions, and apron spacings in spinning which result in the best quality yarns for woven and knitted fabrics.

In drawframe blending an effect called channeling occurs whereby the fibers from each component sliver tend to stay together. This frequently introduces problems in dyeing and in maintaining consistent product quality.

There is evidence in the industry that blending in the opening and picking processes is increasing in order to obtain a more intimate blend. As a result of this method of blending, carding becomes a very critical process because the quality of the yarn and the resultant fabrics will depend mostly on the card sliver quality. Investigations are underway to evaluate combinations of carding variables that will result in higher carding efficiency and product quality and assure that cotton's inherent fiber properties in blends with polyester fibers will be maintained during carding. The effect on carding efficiency and card sliver quality of adding increasing amounts of polyester fibers (20, 35, 50, and 65 percent) to the blend is being established for blends of medium staple cotton and 1.5-denier polyester. Future work will involve the use of 2.25-denier polyester as well as other synthetic fibers.

Research is also being conducted to develop improved carding and drawing equipment and techniques for homogeneous blending of cotton and synthetic fibers to optimize the use of cot-

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ton in textile blends. This research could result in modification of existing equipment or entirely new methods of blending to achieve improved quality and processability.

Other new products, such as improved knitting yarns and knit fabrics, improved fabrics for recreational uses, and chemically modified cotton fibers for greater processing efficiency, will utilize synthetic fibers to some extent during the course of the research. In addition to processing research on cotton/polyester blends, broadcloth and sheeting fabrics having cotton/polyester fiber percentage contents of 90/10, 80/20, 65/35, 50/50, and 35/65 were prepared for the application of different types of durable-press finishes. Measurements relative to fabric strength and tear properties were made. Special emphasis has been placed on comfort-related moisture properties. The properties measured include wicking rate, total absorbency rate, moisture regain, water vapor transport, and total moisture transport. The influence of chemical additives on these properties and means of modifying these properties using reactive additives are being investigated.

PROGRAM AND PROGRESS ON KNITTING RESEARCH

By G. F. Ruppenicker and E. C. Kingsbery[1]

The knitting industry has grown rapidly in recent years. The output of knitted cloth and garments has increased and continues to increase at a rate significantly greater than that of the rest of the textile industry. For example, in 1960, less than 25 percent of all apparel in the United States was knit. Last year, over 40 percent of this market was knit, and it is generally predicted that within the next several years well over half of all the garments produced in this country will be of knit construction.

How has cotton fared in this period of rapid expansion for knits? As recently as 1965, over 50 percent of all yarns consumed in knit apparel was cotton. Since then there has been a steady decline, and in 1970 about 37 percent of the knit apparel market was held by cotton. Later data are not available yet.

Cotton's biggest uses have been in the traditional knitwear markets, such as for T-shirts, undershirts, children's wear, and similar products where the comfort factors we normally associate with cotton are important. In these markets the consumption of cotton has remained relatively stable. However, the greatest growth potential for knits is in the outerwear markets, such as for slacks and suitings. Most of these outerwear fabrics are produced on complex, fine-gage knitting machines that require premium quality yarns. This market is currently dominated by textured polyester yarns.

Although cotton yarns have been used successfully in knitting for many years, their use has been, for the most part, limited to the coarser counts and heavier constructions. Cotton yarns often lack the strength, smoothness, uniformity, and freedom from imperfections to make them suitable for many of these finer gage fabrics. Another limiting factor is the tendency of cotton yarns to shed lint during knitting. Some reports have shown that more than half of all defects in knit fabrics produced from spun yarns may be traced to the accumulation of lint and its sudden injection into the knitting zone. The problem becomes even more acute with fine-gage machines.

To strengthen cotton's competitive position in the knit fabrics market, a research program directed toward developing higher quality knitting yarns that would be suitable for fine-gage knit fabrics was initiated at the Southern Regional Research Center. Studies are being conducted to determine the effect of cotton fiber properties on yarn quality and performance. Cottons grown in different areas may vary widely in strength, length, uniformity, and fineness, depending upon the variety, growing season, weather conditions, and how they are harvested. The proper selection of cottons, based on fiber properties, can result in improved yarns for knitting.

The effect of fiber strength on yarn and fabric properties is illustrated in table 1. Both combed and carded yarns with a range of

TABLE 1.—*Effect of fiber strength on yarn and knit fabric strength*

	Fiber strength (g/tex)	Yarn strength[1] (lb)	Fabric strength[2] (lb)
Average-strength cotton	40	89	93
High-strength cotton	48	103	110
Difference, %	20	16	18

[1] 120-yd skeins of 24/1 yarn.
[2] Bursting strength.

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twist multipliers of from 2.8 to 3.6 were spun from cottons having a difference of approximately 20 percent in fiber strength. Yarns spun from the high strength cotton were approximately 16 percent stronger than those spun from the lower strength cotton and produced knit fabrics that averaged 18 percent greater in bursting strength. Since other fiber properties of the two cottons were very similar, most of the differences in yarn and fabric strength can be attributed to fiber strength.

A related area of research has as its objective the improvement of knittability of cotton yarns through the use of improved processing techniques. Cotton yarns of superior evenness and tenacity, and of the high quality normally required for double knits, have been produced from a selected blend of Upland and high-strength California cottons. In this study, the effects of various mechanical processing variables at carding, combing, and spinning were evaluated in order to determine the optimum processing procedures. Table 2 shows the effect of spinning frame variables on yarn properties. Significant improvements in yarn strength and uniformity were obtained by selection of the proper draft ratios, roll settings, and the use of double-creel rather than single-creel roving.

TABLE 2.—*Effect of spinning frame variables on yarn strength and evenness*

	Skein breaking strength[1] (lb)	Evenness[2] (%)
Single creel roving	97–102	14.7–13.9
Double creel roving	105–110	14.4–13.4
Difference, %	13	9

[1] Range in breaking strength of 120-yd skeins of 24/1 yarn spun with various machine settings.
[2] Range in yarn uniformity as measured by Uster evenness tester.

Similar studies are underway with blends of cotton and polyester. Efforts are being made to establish the best blend levels and blending techniques for producing yarns for knitting.

Another approach is concerned with minimizing the deficiencies of cotton knitting yarns through chemical treatments. This work is being done under contract at the Philadelphia College of Textiles and Science. Various treatments have been applied to cotton yarns from both aqueous and solvent systems, including cellulose ethers, polyvinyl chloride, polyvinyl acetate, polyethylene oxide, and others. The application technique was by single end padding, but probably could be adapted to treating beams of yarn for warp knitting.

Many of the treatments improved strength and smoothness and reduced the linting tendency of the cotton yarns. Table 3 shows a comparison between untreated yarn and yarns treated with two of the most promising finishes. The vinyl resin was applied from a perchloroethylene solution and the hydroxypropyl cellulose from a water solution. Both were easily removed from the knitted fabric, the former by solvent extraction in perchloroethylene and the latter by a cold-water scour.

TABLE 3.—*Comparison of untreated and treated cotton knitting yarns*

Treatment	Solvent	Single-strand breaking strength (g)	Coefficient of variation[1] (%)
Untreated		180	12.2
Vinyl resin	Perchloroethylene.	198	6.0
Hydroxypropyl cellulose.	Water	203	8.4

[1] An indication of yarn uniformity calculated from breaking strength values.

Yarn breaking strength was increased significantly. There were also considerable improvements in uniformity, as indicated by the coefficients of variation calculated from breaking strength values. Yarns treated with the two finishes had good flexibility, and lint shedding was greatly reduced.

There appear to be many opportunities for cotton in the knit fabric market. Much depends upon the development of improved yarns to meet the stringent requirements of fine-gage, tightly knit constructions. Cotton has many desirable properties, including good absorbency and breathability, which give cotton garments a comfortable feel, especially when worn next to the skin. Fabrics knit from cotton yarns have good cover; that is, they seldom have the "see-through" effect common in many knit fabrics produced from filament yarns. Another advantage of cotton knits is that they have excellent snag resistance. Snagging is a major problem with many of the double knit suitings on the market today.

STATUS OF FLAME-RETARDANT STANDARDS FOR APPAREL AND HOUSEHOLD GOODS, AND THE AVAILABILITY OF FLAME RETARDANTS TO MEET THE STANDARDS

By Jerry P. Moreau[1]

In 1953 Congress passed the Flammable Fabrics Act to curtail the large numbers of injuries resulting from easily ignited fabrics. This legislation was designed to eliminate only the highly flammable fabrics or so-called torch clothing. The test method devised to screen this type of fabric is officially called CS 191–b, but is commonly known as the 45° test because of the angle at which the sample is held during testing. The sample is exposed to a flame for 1 second, and the time required for the flame to travel a distance of 5 inches is recorded. A flame-spread time of less than 4 seconds is considered intensely flammable. A flame-spread time of greater than 7 seconds is usually considered normal or passable. In-between times are called intermediate. From this brief description of the test, it becomes apparent that it is not a very severe one. However, it does the job it was designed to do—eliminate the highly flammable fabrics.

Within the last decade, there has been increased interest in flame retardancy and fire prevention because of the alarming statistics concerning fires. In 1970, for example, there were an estimated 12,200 lives lost and $2.63 billion in property damage as a result of destructive fires in the United States. Approximately 3,000 to 5,000 lives are lost annually, specifically from fires that involve clothing textiles. Annual statistics on burn cases include 2 million burn accidents, 12,000 to 13,000 deaths, 10,000 hospital beds occupied daily by burned victims, burn patients hospitalized for an average of 70 days at $160 to $180 per day, and hospital costs for all burn victims totaling approximately $1 billion.

Sensing the growing demand for more stringent legislation, Congress amended the Flammable Fabrics Act in December 1967..This revision put teeth into the act of 1953 by giving the Department of Commerce (DOC) the authority to revise and strengthen current standards, set new standards, and extend the scope beyond the most flammable clothing to include all personal and household fabrics that may be considered hazardous. The DOC also has the authority to conduct research on the flammability of products and to develop test methods. The amended act also gave the Department of Health, Education, and Welfare the authority to study fire hazards by investigating deaths, injuries, and economic losses, and to determine which products are hazardous. The Federal Trade Commission is the enforcement agency which sets the rules, inspects for possible violations of the act, and penalizes the violators.

Recent statistics show that a large proportion of deaths and injuries resulting from apparel-burn cases involved children 5 years of age and younger, and the elderly, 66 years of age and older. Sleepwear for children in this age bracket seems to be particularly hazardous; incidence of burn injuries involving nightwear is almost four times greater than the number predicted from the population distribution. Data such as these have led to issuance by the Department of Commerce of the Children's Sleepwear Flammability Standard, which requires that all children's sleepwear from sizes 0 to 6X, must pass a vertical

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flame test after 50 home laundering cycles. The samples must be tested in the bone-dry state, using a 3-second flame exposure. The average char length should not exceed 7 inches, and no sample must burn the entire length. This standard was adopted on July 29, 1971, and is called the DOC FF 3–71 standard. All goods manufactured after July 29, 1973, must comply fully with all provisions of the standard. Goods manufactured before July 1973, and which do not comply with the standard, must be labeled "Flammable (Does Not Meet U.S. Department of Commerce Standard DOC FF 3–71). Should not be worn near sources of fire."

There are now several flame-retardant finishes on the market which are designed to impart durable flame resistance to cotton fabrics so that they meet the standard. Most of the chemicals used for this specific purpose contain phosphorus. There are two types of finishes which are widely used commercially. One is based on an organophosphonopropionamide and is commonly known as Pyrovatex. The other is tetrakis (hydroxymethyl) phosphonium chloride, commonly called Thpc. The latter compound was first utilized as a flame retardant for cotton at the Southern Regional Research Center approximately 20 years ago. There are several flame-retardant finishes based on Thpc. One such finish which has recently received national publicity is commercially known as Fire-Stop. It was developed by United Merchants and Manufacturers in cooperation with the Southern Regional Research Center and Cotton Incorporated.

Another flammability standard issued by the Department of Commerce in April 1970 is DOC FF 1–70, for carpets and rugs. This standard, which states that all large carpets and rugs (over 24 square feet) must pass the pill test, became effective in April 1971. If smaller carpets and rugs do not pass the test, they must be properly labeled. In the pill test, a small methenamine tablet is placed in the center of a 8-inch-diameter circle on the test sample, and ignited. The specimens are tested under bone-dry conditions after 10 home launderings. A specimen passes the test if the charred portion does not extend to within 1 inch of the edge of the circle. Cotton rugs and carpets can meet this standard by treatment with Thpc finishes or similar finishes. Rugs and carpets do not require as much flame-retardant chemical add-on, since the standard requires durability only through 10 laundering cycles.

The most recent standard imposed by the Department of Commerce is DOC FF 4–72, for mattresses. The standard was issued in June 1972 and becomes effective in June 1973. The test used in this standard is commonly known as the cigarette test. It consists of placing 18 lighted cigarettes in specified locations on the mattress. If the charred area extends more than 2 inches in any direction from the nearest point of the cigarette, the mattress fails.

Mattresses may be treated with flame-retardant chemicals in two ways. The cotton ticking or covering may be treated with a Thpc-type finish in order to protect it against flaming. Nondurable flame-retardant finishes, which are less expensive, may be used, since mattresses are not laundered. The cotton batting inside the mattress may be treated with chemicals which protect the mattress against smoldering combustion by dissipation of heat. Researchers at the Southern Regional Research Center have recently shown that some compounds containing boric oxide are particularly effective against this type of hazard.

Another recently imposed standard, which is controlled by the Department of Transportation, is known as the Federal Motor Vehicle Safety Standard Test Method No. 302. This standard covers all interior materials in passenger cars, multipurpose passenger vehicles, trucks and busses. The effective date for the standard is September 1972. The test used to meet this standard is a horizontal burn-rate test. The test involves mounting the fabric sample in a metal frame, then placing it in a standard test chamber. The test sample is ignited by a gas flame and the burn rate is calculated. If the burn rate does not exceed 4 inches per minute, the sample passes.

Because the interior of a motor vehicle contains many kinds of fabrics, the chemical finishing or treatment of these fabrics will depend on the type of fabric, weight, and construction. A product developed at Southern Regional Research Center called Cotton Flote is used in seat cushions. It may be treated in the same manner as the batting used in mattresses. Since most materials inside of an automobile do not have to be laundered, they may also be treated with

nondurable flame retardants. Another treatment that reduces the flammability of upholstery fabrics is backcoating. One such system used in backcoating is a copolymer of an acrylic and vinylidene chloride. A bromine containing phosphate may also be added to the system to increase flame resistance.

There is a considerable amount of research designed to determine if a need exists for standards in other areas such as draperies, bed linens, blankets, dresses, shirts, pants, and so on. A standard (DOC PFF 5–73) has already been proposed for children's sleepwear in sizes 7 through 14. Also, in a study by the National Fire Protection Association, it was reported that in a 2-year period, of 1,447 cases of fire-related fatalities in which cause was known, 237 deaths were attributed to upholstered furniture fires caused by persons smoking. Other data show that in all fabric-related fires, furniture upholstery was the first material ignited in over 25% of the fires. As a result, a need for a standard was issued in November 1972.

Also regarding fabric flammability, Senate bill 3419 was recently passed, authorizing the establishment of the Consumer Product Safety Commission to deal with all aspects of product safety. The new Commission will coordinate the duties which were previously assigned to several agencies involved in fabric flammability.

Although the development of test methods and implementation of flammability standards may be a slow process, tremendous improvements have been made in the field of flame retardancy. Improvements have not only been technological, but the increased interest and publicity on flame resistance has educated the consumer with regard to fire and burn safety. Hopefully, as a result of flammability standards, it will be possible one day to reduce the loss in property and to eliminate the loss of lives caused by fire.

In conclusion, flammability standards have already been imposed on children's sleepwear (sizes 0 to 6X), carpets and rugs, mattresses, and motor vehicle interiors. Standards are forthcoming in other areas as well. The types of chemicals used to finish cotton products to impart flame resistance have been presented.

IMPROVING THE COTTON MARKETING SYSTEM

By James E. Haskell[1]

Many of the problems confronting today's cotton producer are associated with his inability to match the sophistication of his manmade fiber competitors in total production-marketing strategy. To the extent this failure is caused by differences in economic organization, he may do well to consider alternative organizational arrangements that can be initiated by producers and that might benefit both cotton growers and their mill customers.

In an oversimplified but fundamental sense, the goal of this research was to suggest directions toward which U.S. cotton growers might move to remain viable in face of the threat posed by declining Government assistance, rising off-farm costs, and competition from synthetic fibers. The examination of organizational options open to producers was limited to those within the boundaries of present Government policies and legislation. Efforts were made to determine whether or not producers could link their operations more directly with those of domestic and foreign mills in ways that would be mutually advantageous and more efficient than present organizational arrangements. Consideration was given to how the industry could attain improved order and flow in cotton marketing processes and better price and supply stability.

The primary source of information for this study was unstructured personal interviews with key people in each major segment of the cotton industry—producers, ginners, warehousemen, merchant-shippers, and mill buyers. These informal meetings were designed to explore and evaluate ideas and opinions of each group which might serve as an information base on which to render judgment.

AN ALTERNATIVE SYSTEM

Analysis of concepts accumulated from the various segments of the cotton industry points to a system with the potential for reducing off-farm costs on the one hand, and increasing the similarities of cotton versus synthetic fiber procurement on the other. To this end, a producer-oriented marketing system is proposed, based on centralized ginning concepts and with the notions of forward contracting, mechanical classing and sampling, seed cotton blending, and uniform-density bales playing strong supporting roles.

While most of these concepts need no explanation, the term "central ginning" carries various connotations, and therefore should be defined more precisely. As used in this study, central ginning merely refers to a method of gin operation whereby sufficient quantities of seed cotton are stored to keep gins operating at near-capacity rates throughout the ginning season. Longer ginning seasons and higher capacity gins are not prerequisites for central ginning, but either one or both may become economically feasible when large quantities of seed cotton are stored.

Much of the interest in central ginning came from producers in low-rainfall areas of the Cotton Belt. Recent commercial use of turnrow storage has supported experimental results showing that seed cotton can be stored safely in those areas without protection from the weather. Since central ginning requires seed cotton storage, it would seem that low-rainfall regions would be most suitable for its use. However, during the 1972 season, substantial quantities of seed cotton were successfully stored in the San Joaquin Valley and Mississippi Delta, indicating that with proper protection from the elements, seed cotton can be stored anywhere in the belt. The momentum created by proven storage techniques may well give producers the impetus to overcome many of their processing and marketing problems.

Central ginning offers numerous potential benefits to the cotton industry, most of which relate directly to other suggested changes in the handling-marketing system. The most obvious advantages are (1) substantial reductions in per unit ginning costs, (2) orderly marketing, (3)

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reduced handling and marketing costs, and (4) seed cotton blending.

The concept of blending seed cotton offers new potentials for effective cotton merchandising efforts. Cotton merchants and marketing cooperatives often encounter problems in matching requirements of domestic and foreign mills with the qualities available from cotton ginned for individual growers. They also have problems maintaining the uniformity in quality that mills desire, either among bales in lots, or within individual bales. This problem is especially apparent in areas of unpredictable weather and multiple cotton varieties. Blending seed cotton would enable marketing firms to more accurately deliver the qualities, quantities, and uniformity that mills require.

The textile industry's demand for greater uniformity of quality characteristics, and the ability of synthetic fibers to meet that demand, should intensify cotton industry efforts in the same direction.

Workings of the System

While the general attributes of a totally new processing and marketing system might be loosely described, its intricate mechanical operations are necessarily hypothetical and subject to improvement. Nonetheless, it is important to describe in as much detail as possible how such a system might operate in tomorrow's marketing environment. Most of the detail has been furnished, in one form or another, by producers, ginners, cotton buyers, and marketing firms.

The system would be composed of producers, fewer but fully utilized gins, fewer but more strategically located warehouses, marketing agencies, and the mills. It would require changes in the physical flow and handling of cotton, adjustments in existing trade rules and practices, and new concepts of organization and coordination of industry functions.

Changes in the physical flow of cotton from farm to mill would begin at harvest through temporary storage of seed cotton on the turnrow or central gin site. Samples taken from the stored seed cotton could be ginned so that quality and estimated quantity of lint and seed could be determined as the basis for grower payment. And since the ginner would know the qualities, quantities, and location of seed cotton supplies, he could coordinate blending and ginning activities with forward sales commitments made by the marketing agency.

The portion of the crop that is ginned but not yet sold would be concentrated and stored in even-running lots at the warehouse complex. This feature (in combination with others to be discussed) would enable larger volumes to be stored in a given warehouse, significantly improve conventional retrieval techniques and reduce shipping delays.

In contrast to present trade practices, there would be no need for repeated sampling of lint cotton bales. One-time automatic samples, representative of the entire bale, could be taken at the gin. Blending seed cotton before ginning would create the uniformity required for effective automatic sampling in areas that are not blessed with natural, uniform cotton. High-volume central gins would also be equipped with universal-density bale presses to eliminate the need for recompression and excessive handling. Both of these changes would allow for substantial improvements in bale packaging, and therefore mill acceptance.

Most producers and many of the mills would also support a move toward one-time weighing of lint cotton bales. Cotton could be weighed immediately after ginning by a licensed or bonded employee. That weight would stay with the bale throughout the remainder of the marketing process. It would eliminate the costs involved in reweighing and would reduce the moisture regain problem that often works to the disadvantage of producers.

Many of the advantages attained through seed cotton storage, blending, automatic sampling, uniform density, and single weights result from the use of each concept in combination with the others. For example, automatic sampling in the absence of seed cotton blending may not be practical in areas of nonuniform cotton. And since one advantage of universal-density bales is to improve packaging and appearance, automatic sampling is necessary to eliminate the need for cutting open the new package.

Coordination of gin-compress relationships is central to lowering off-farm costs and improving the total bundle of goods and services ultimately delivered to the mills. It makes little economic sense to perpetuate the existing relationship, which is unnecessarily expensive and which re-

sults in a product leaving the compress in poorer condition than when it left the gin. Why spend large amounts of money to wrap and tie out a bale, press it, weigh it, sample it, and load it, then send it from gin to compress where it is unloaded, reweighed, resampled, unwrapped, recompressed, and reloaded? The alternative presented here is merely to do these things right the first time, at the gin, to prevent having to do them again.

Of critical importance in this study was the determination of how the various industry groups view cotton marketing issues, particularly those concerned with linking production to the market. Some of the issues such as joint ventures, producer ownership of textile mills, and bargaining received only limited support as potential solutions to marketing problems. However, the positive response toward functional integration and forward contracting indicates that each may play an important role in an improved marketing system for cotton.

The trend to increased contracting does not appear to be a temporary phenomenon. Many industry leaders feel the practice will become even more widespread if and when the Government winds down its support role in cotton. It might be one of the few options available to mills who want to assure themselves of a continued adequate supply. If this forecast is correct, forward contracting would likely become an essential cog in the system proposed here.

Domestic and foreign mills could make their quality and quantity requirements known by establishing contracts with the producers' marketing association. This information could then be relayed back to the gins and individual growers through contracts or binding marketing agreements. The varieties planted, and perhaps even cultural practices, may be conditioned by mill quality requirements. Ginning methods, especially those dealing with drying, lint cleaning, and blending would also be directed by previously negotiated mill contracts with the marketing agency.

Contracts between the mills and marketing agencies would be preferred to those between mills and gins. The latter arrangements might cause excessive competition among gins for mill contracts that would break down the coordination between marketing and ginning levels. In addition, a marketing agency with several central gins under its jurisdiction would seem to be in a better position to meet varying contract requirements than would single gins operating independently.

In order for individual growers to effect the potential savings from such a system, it is necessary that most of the control be in their hands. But to say that growers, acting collectively, should exercise control through joint ownership of processing and marketing services raises questions as to the type of ownership patterns that would result in the most effective system. One method might be a quasi-federated structure where growers would own the gins and warehouse complex, and the gins would own and control the marketing association. A more centralized system would have the growers own the marketing association, which, in turn, would control the ginning and warehousing activities.

From a producer interest standpoint, it would seem a centralized decisionmaking complex could most effectively meet the requirements of the emerging fiber distribution system. Sophisticated marketing decisions must be based on the most up-to-date information flow available. These decisions are dependent not only on what's happening in South Carolina, but also in China, Japan, Bangladesh, and elsewhere. It would be difficult to expect individual gin decisions to reflect changing conditions all over the world. Under a federated system where marketing decisions are largely determined at the local gin level, excessive fragmentation might result in marketing efforts less precise than those made by centralized marketing agencies. Also, excessive misdirected power at the local level may cause the gins to compete with one another, rather than work in concert with their marketing partner.

Structural Implications

Movement toward a marketing system based on central ginning and producer control has obvious structural implications for the various industry groups. The most apparent adjustment would involve the ginning segment of the industry, where the trend toward fewer and larger gins is already well known. With widespread acceptance of central ginning, this trend would be greatly accelerated. Gins with annual volumes of 50,000 bales or more are not out of the question.

The direct-marketing implications of such a system would undoubtedly affect the operations of merchant shippers and other intermediate buyers and sellers of raw cotton. Their functions of assembly, financing, storage, and merchandising would be largely absorbed by producers through their own marketing agencies, warehouses, and gins. Newly established seed cotton loan programs may provide financing assistance.

In terms of retaining identity the worst fate would befall the compresses. Since gins would be equipped with universal-density bale presses, the need for recompression would be eliminated. Of course, the rate of decline in compression needs will vary with the rate of acceptance of central ginning.

The warehousing segment would experience some changes, but storage of cotton in some form would still be required. Lint cotton storage might not be needed for those bales shipped directly to mills, but unless gins had volume enough to operate most of the year, some storage of lint cotton would be required for that volume ginned but not shipped immediately. We might well see a movement toward ginning-warehouse complexes at one location; a number of these are already in existence.

SUMMARY

A producer-oriented marketing system similar to that described here appears to have substantial promise and appeal. The chief advantages of the system are as follows:

1. Cotton producers, through their marketing agencies, would have a direct link to the mill-consuming sectors of the industry. Adjustments to changing mill requirements could be made more quickly and accurately.

2. Reduction of off-farm costs. Producers could be the major beneficiaries of changes resulting in lower costs of ginning and handling. Empirical studies have shown that significant cost savings are possible through central ginning and related practices.

3. Reduction of marketing costs. Costs of moving cotton from the farm to the mill would be reduced through fewer changes in ownership, less handling, sampling, and weighing, and fewer concentration centers of raw cotton supplies.

4. From the mills' standpoint, the cotton procurement system would more nearly approach that of man-made fibers. Cotton bales delivered to mills would be more uniform as to quality, density, size, and appearance.

5. Mill demand could be met more effectively through seed cotton blending and orderly marketing. The practice of custom ginning for particular mills would become an increasingly important feature.

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